COMBUSTION

Vol. I, No. 2 | AUGUST 1929 | 25 c. a co

Engineering Library

U. S. RUBBER CO.

Steam Pressures for Industrial Plants Determined by Rational Factors

By W. A. SHOUDY

Personnel — A Factor of Increasing Importance in the Modern Power Plant

By ROGER D. DeWOLF

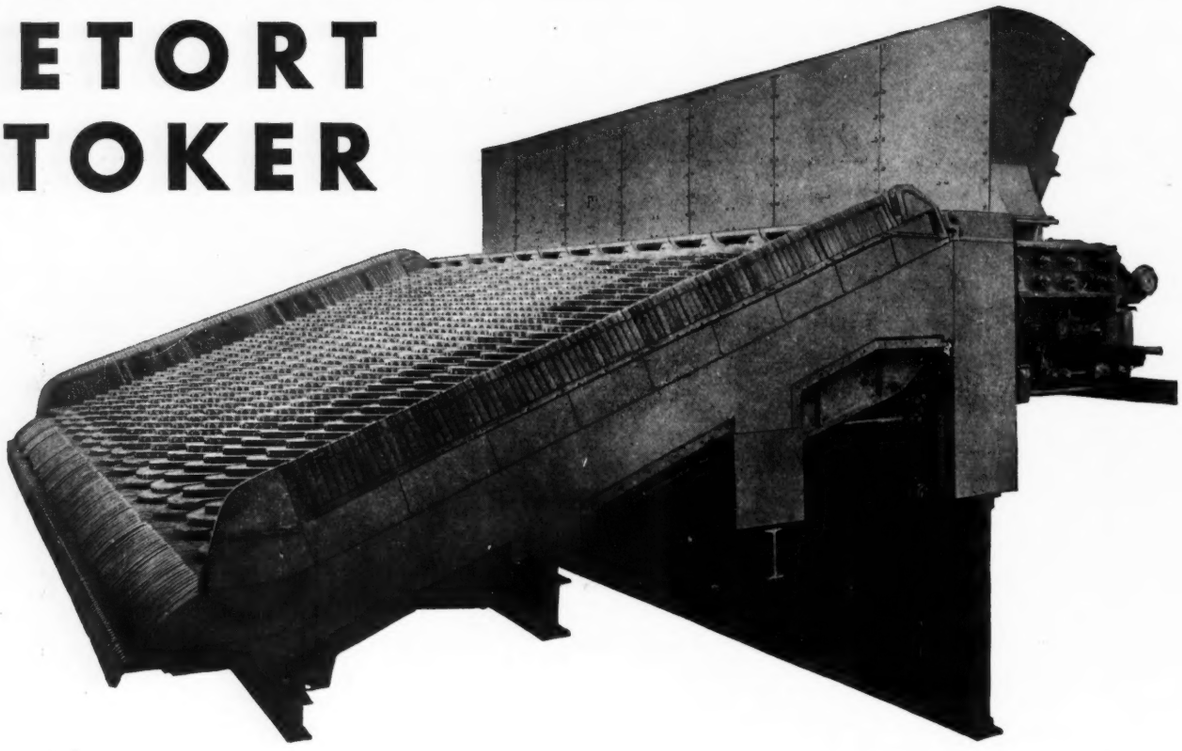
Power Station Practice in Great Britain

By DAVID BROWNLIE

Other Articles in This Issue by

R. D. FOLTZ • OTTO de LORENZI • H. G. EBDON • R. C. DENNY

A BETTER MULTIPLE RETORT STOKER



The C-E Multiple Retort Stoker possesses important advantages of design and construction which are evident to those who have had the opportunity to examine it. • The character of its performance is revealed in the operating records of existing installations. • Translated into actual performance, the results of the many new features embodied in this stoker are —

NOTABLE SMOOTHNESS AND RELIABILITY OF OPERATION • LOWER AIR PRESSURES
EASIER AND MORE ACCURATE CONTROL OF MOVING PARTS
HIGHER FUEL BURNING CAPACITY • IMPROVED OPERATING EFFICIENCY
MORE EFFECTIVE ASH DISPOSAL • LOWER MAINTENANCE COSTS

Because of these results, the performance of the C-E Multiple Retort Stoker represents a definite advance over present-day standards in the multiple retort stoker field.

• • •

Your copy of the new catalog, describing the C-E Multiple Retort Stoker, is awaiting your request.

COMBUSTION ENGINEERING CORPORATION
International Combustion Building • 200 Madison Ave., New York
A SUBSIDIARY OF INTERNATIONAL COMBUSTION ENGINEERING CORPORATION

COMBUSTION

Vol. 1 AUGUST 1929 No. 2

CONTENTS

Feature Editorial—

Engineers Should Be More Active in Public Life 21

Feature Articles—

Steam Pressures for Industrial Plants Determined by Rational Factors 23
by W. A. Shoudy

Upper Drums of Large Modern Boilers Require Special Supports 27
by R. C. Denny

Personnel—A Factor of Increasing Importance in the Modern Power Plant 30
by Roger D. DeWolf

Power Station Practice in Great Britain 34
by David Brownlie

The Refractory Furnace Developed for Modern Practice 39
by R. D. Foltz

Flexibility of Pulverized Fuel Installation of Advantage for Large Units 43
by Otto deLorenzi

Equipment of Highest Thermal Efficiency Not Always Justified for Industrial Steam Plants 48
by H. G. Ebdon

Errors in the Measurement of the Temperature of Flue Gases 33

Editorials—Facing Forward—Business Is Good—An Example 22

Chart—How to Calculate the Loss Due to Heat in Dry Flue Gas 46

News— Giant Power Plant for Industrial Chicago 52

Pertinent Items of Men and Affairs 53

New Catalogs and Bulletins— A Review of Current Trade Publications 55

Review of New Technical Books 56

New Equipment—

A New Centrifugal Feed Pump for High Pressure Boiler Feeding 57

Blow Off Valves for High Pressure 57

Boiler Construction that Eliminates Seams 58

Patents— Recently Granted in United States and Great Britain 59

Advertisers' Index 63

CHARLES MCDONOUGH
Business Manager

CARL STRIPE, *Editor*
R. C. DENNY, *Technical Editor*

H. STUART ACHESON
General Representative

Published Monthly by IN-CE-CO PUBLISHING CORPORATION *A Subsidiary of*
INTERNATIONAL COMBUSTION ENGINEERING CORPORATION

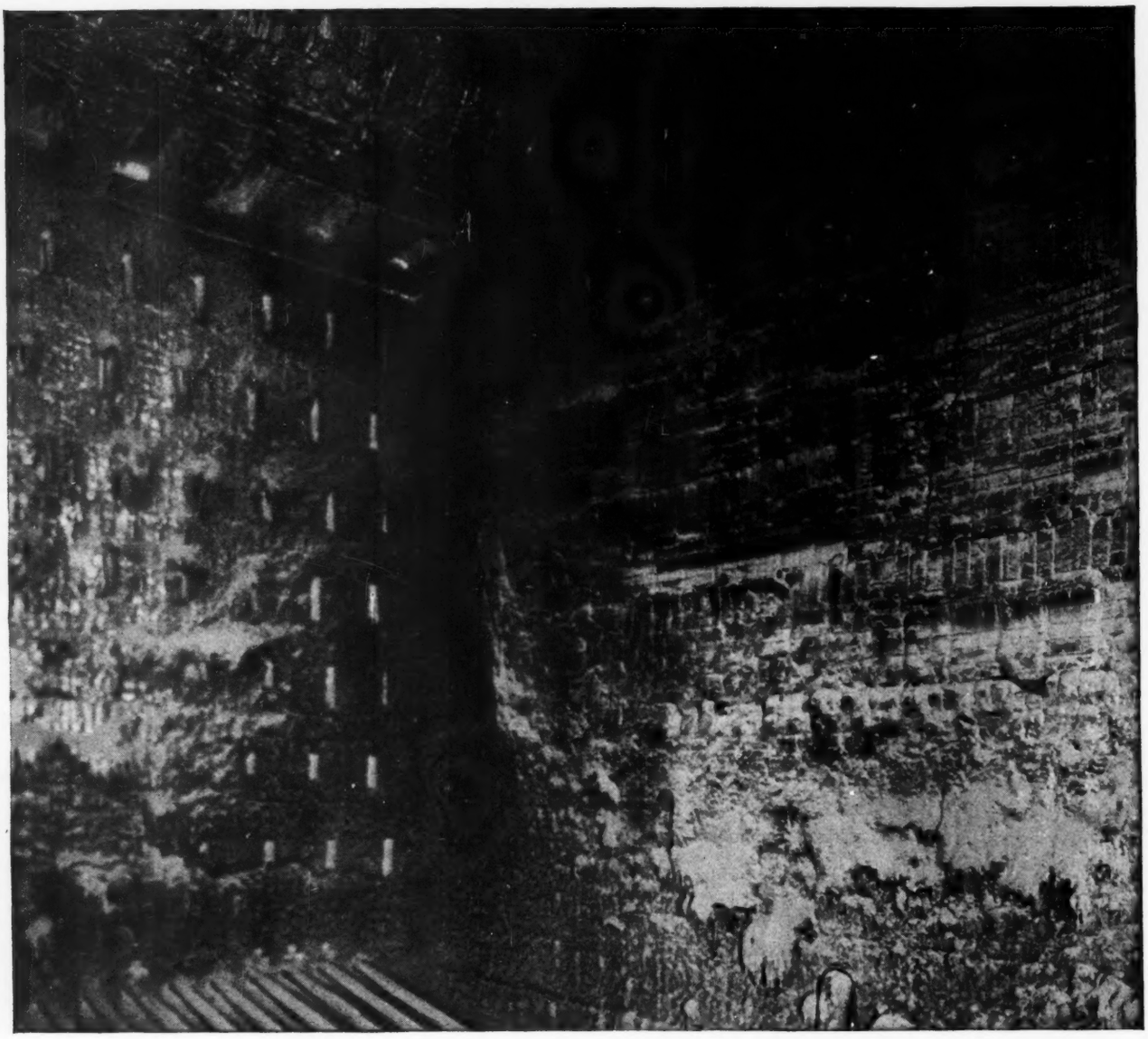
NEW YORK
International Combustion Building
200 Madison Avenue

LONDON
Africa House
Kingsway, W.C. 2

SUBSCRIPTIONS, including postage, United States and Canada, $2.00 a year, Great Britain 8 shillings. Other countries, $3.00. Single copies: United States and Canada, 25 cents. Advertising rates furnished upon application.

Copyright 1929 by In-Ce-Co Publishing Corporation, New York. Printed in U. S. A. Publication office, 200 Madison Avenue, New York.

NUMBER OF COPIES PRINTED THIS ISSUE, 12,055



Again

The Illuminating Company Repeats—*'24, '25, '27, '28 and 1929*

The Cleveland Electric Illuminating Company's record of repeat orders for Detrick Air-Cooled Walls speaks for itself:

1924—Three installations at 20th Street Heating Plant
1925—Four at Avon Power Station
1927—Another at 20th Street
1928—Two more at Avon Station
1929—Still another two at Avon

The illustration shows a Detrick Wall and Arch after two years of service at the Avon plant—*without repairs.* Need we add any comment?

M. H. DETRICK COMPANY
140 South Dearborn Street, Chicago

New York...50 Church St.
Detroit.....Murphy Bldg.
Pittsburgh....Empire Bldg.
San Francisco...Russ Bldg.

DETRICK ARCHES & WALLS

"Better than the Refractory of which They are Made"

COMBUSTION

Vol. 1 August 1929 No. 2

Engineers Should Be More Active in Public Life

IT IS time engineers bestirred themselves to contribute of their abilities to the administration of government. Examples there are, but of followers a mere handful. President Hoover is an engineer, as is Governor George H. Dern of Utah, but the representation of the engineering profession is in sad contrast to the representation in government of the legal profession.

If a financial competence is one requisite for undertaking public office at a nominal salary, surely there are numerous engineers who have sufficient wealth. If the thrill of tackling a big job must attract such engineers, government administrative posts offer problems like the famous tasks of Hercules. The federal, state and municipal government organizations all offer such opportunities for public service.

To the engineer, government service has, perhaps, seemed distasteful. His training has been in securing efficient results, not in the wiles of politics. His skill has consisted chiefly in ability to solve complicated problems of fact, not in the sophisms of debate. He has never been beguiled by mere pretense of activity, but always concerned with the orderly execution of a definite plan. He has been inured to compromise, to be sure, but always with absolutely fair consideration of conflicting factors. Public administration has seemed to him a maelstrom of savagely conflicting personal ambitions, rather than organized effort.

Yet, after all, is the situation any different from that presented by business in general? Do not the very complications of political administration offer exactly those problems which the engineer is trained to solve?

Engineers can bring to public office a splendid personal equipment. Their method of work has universal application. The method is simple, as successful working methods usually are. First comes the establishing of an objective, a clear statement of the problem; next a concentrated study of all available facts relating to it, and a thorough canvassing of unknown factors; followed by a definite plan of action, and an organization of men and machinery for executing that plan. Then action, with unswerving purpose to gain the objective; and finally, upon completion, a check-up to prove the work.

This method is familiar to all business executives. It is the trick of modern business success; and it is also the method in which engineers are trained. Engineers have signally succeeded in the administration of commercial businesses; they can also succeed in government business.

Why should not this method be applied to the administration of public affairs? Are the familiar human weaknesses of politics so strongly intrenched that they will not yield to the methods that have achieved engineering and business success? The practice of chicanery is fast working out of the nation's business structure, and is being replaced by system, sound economics, and humaneness. The business of public administration must fall in line; is already falling in line, in notable instances. The acceleration of the movement will depend very largely on the determination of able and upright men to help it along by their personal services. And not the least of such contributions will be the ability, the knowledge, and the character of engineers, when thrown into the scale on the side of economy, clean politics, and the general welfare.

·EDITORIAL·

Facing Forward

LET us not spend too much time looking backward at our achievements. Our destiny lies ahead. What we have so far accomplished is but the foundation and the training for a swifter and surer advance.

A feature article in this issue refers to the fact that the use of higher steam pressures was delayed only by commercial demand. When the economy of high pressures was commercially recognized, the engineers were ready with practical designs. Are we ready now for still further advances in steam generation, so that when the demand comes we can promptly fill the order? And, if our progress along conventional lines has reached that critical point where technical progress is barred by uneconomic expense, are we preparing for advance along unconventional lines?

The business structure of modern industry is essentially competitive. The public demands, and will pay for, economic betterment in new products, whether they are conventional or unconventional. We may be very sure that many minds are today concentrating on the problem of cheaper production of power. He who spends too much time complacently contemplating past achievements, even though they be yesterday's, will be passed by the man whose mind is forging ahead with the solution of tomorrow's problems.

Progress is at a faster pace today than ever before. There is little value in trade secrets when newer methods are developed over night. Progress today demands the frank disclosure of new methods, new features and new details. Engineering has no patience with secrets, it demands detailed and accurate knowledge. He who attempts to keep up with progress by discovering what his contemporaries are doing, will find himself grasping at shadows—the procession long since passed along.

For progress, let us turn from the past and face the future. Caesar burned the bridges behind him to prevent retreat. When the opportunity of business demand knocks at our doors, let us not protest that the demand has never been made before; let us not even be content with the time honored formula of "I'll try." We must accept the challenge, have faith in ourselves, and strike out boldly.

That man, or that business organization, will rise to success, whose habit is thoroughness, whose policy is fair dealing, and whose thoughts are busy with the improvement in today's product for tomorrow's demand.

Business Is Good

THE year 1929 has developed the greatest indusr trial activity that the United States has eveknown. Robert P. Lamont, Secretary of Commerce, states that in the first four months of the year there has been a gain of 12 per cent in steel ingots over the highest previous production.

Automobile production, copper and tin outputs, silk and cotton have all jumped ahead. Machine tools orders advanced 44 per cent. Freight car loadings were up 4 per cent; and new orders for fabricated steel increased 28 per cent, reflecting the large volume of heavy construction and engineering projects.

The Secretary's report spells prosperity, and an underlying strength of business that assures us we are right now in a period of business expansion that has never before been attained.

An Example

A FEW years before the world war, Lewis S. Palen, who served for many years in the Chinese Imperial Maritime Customs, entertained at his Antung residence in Manchuria, an American mining engineer who was on an inspection trip, looking over a Korean mine on the Yalu River.

There were opportunities in the evenings for long talks, and both men could contribute many interesting experiences in foreign lands. Their conversations led to a discussion of the quality of government administration in various countries, and of administration by men of business training in comparison with that by men whose point of view was largely centered on political advantage. The engineer said he was convinced that he should return to the United States, seek out some such position as the secretaryship of a municipal or larger political unit, and throw into it the qualities of business training that he had learned in the successful pursuit of his profession.

There, in the midst of the strange scenes of Asia, looking out on a panorama of ancient temples, primitive rice fields, and rugged mountains, these men talked with a wide vision of our modern civilization. From this old world meeting, the visitor returned to Europe and thence, back to his native land, to put into effect, with his own person, the ideals he had formulated. He accepted work of a public character in connection with the world war, was thereafter appointed to the post of Secretary of Commerce of the United States, and is now our President, Herbert Hoover.

Steam Pressures *for* Industrial Plants Determined *by* Rational Factors

By W. A. SHOUDY
Consulting Engineer, New York

LESS than fifteen years ago, Robert Cramer, in a paper before the American Society of Mechanical Engineers, showed that if central stations would adopt for their operating conditions, 600 lb. pressure and 600 deg. total temperature instead of the then current 200 lb. and 600 deg., a fuel saving of 11 per cent would be accomplished. The discussion that this paper developed is of special interest if read today, because of expressions like the following: "It will be necessary to use economizers . . . and take extra precautions against steam leakage.—It would mean the substitution of a welding gang for steam fitters on the larger work.—It is certain that if pressures are increased, the high pressure stages (of the turbine) are going to become less efficient.—Assuming that the gains indicated . . . can be realized, can apparatus be constructed of such cost . . . that the total operating gain . . . and general reliability will make the proposition a profitable one?"

There is absolutely no reason for selecting a high steam pressure for an industrial plant on the ground that a neighboring plant is so designed, or even because many industrial plants are using high pressures. The determination of proper steam pressure should not be made arbitrarily but with due consideration for certain vital factors. Selection of steam pressure will be rational, and the results will be economical, only when the quantity and pressure of process steam is accurately forecast, and in connection with the amount of power required.

Three or four years prior to this paper, Ferranti, in England, had made a similar proposal, but had also suggested reheating between stages. At that time considerable study was being carried on by others, but it was only five years ago that the first 600 lb. boiler started operation in this country, and almost simultaneously operation at 1,000 lb. began in another central station. Today there are now operating, or building, thirteen central stations using 600 lb. pressure, or higher, of which seven will operate at above 1,000 lb. pressure. Five industrial boiler plants are now operating at pressures of 600 lb. or higher, and five more are in process of construction. Two of these plants operate at pressures above 1,000 lb., and three for such pressures are in construction. One hundred and fifty industrial plants, with boilers designed for 300 lb. pressure, or higher, make this pressure no longer high, but rather place it in the moderate pressure class.

We cannot class as pessimists those who discussed Cramer's paper fifteen years ago, for they merely pointed to difficulties that had to be overcome. Today we have economizers, we weld our pipe joints, and the turbine designers have struggled with high pressure stage design. Someone has said that the engineer will solve any problem when the public shows a disposition to pay the bill. The difficulties facing higher steam pressures were not unsurmountable fifteen years ago,—the public was not at that time ready to pay the price

The World War changed these conditions. Fuel economy became almost a national slogan, and the electric utilities led the way. The increased cost of labor and fuel compelled the most rigid economy. They turned to the engineer and agreed to pay the bill, and the engineer increased steam pressures as rapidly as manufacturers could turn out the equipment. The design of all equipment was seriously affected, and some of the most puzzling problems were not with the major equipment, but with the boiler trimmings, valves, etc. That high steam pressures are commercially practical there is no doubt today; operating difficulties thus far have been minor. This is undoubtedly due to the fact that both manufacturer and operator have had a wholesome respect for the pressures they were dealing with. Familiarity has not yet bred disrespect,—when that time comes we may expect operating troubles.

Very few truly comparative figures of the cost of high pressure plants have yet been made public, but it is generally conceded that there is only a small increase in cost for a high pressure electric generating station over one for moderate pressures, the increase being of the order of 6 or 7 per cent. The pressure parts are, of course, very much more expensive, but they are only a fraction of the cost of the entire station. For boiler plants without power equipment, high pressures will require an additional investment of the order of 15 or 20 per cent, but at present there is a great dearth of accurate comparisons.

It is not the purpose of this article to discuss, in detail, the use of high pressures for the generation of electric power in large quantities. This phase of the problem has been amply discussed before the engineering societies. It is, rather, an effort to show to what extent high steam pressures may affect the

smaller plant. Many industrial plants have wisely chosen higher pressures, but others can make no gain by abandoning their present low pressure operation.

It is hoped that the author may be pardoned if he first discusses, in an elementary way, a few basic principles that may be common knowledge, for without agreement on these principles, the discussion may be misunderstood.

All power calculations dealing with vapors, of which steam is one, are necessarily complicated. At times the vapor acts as a gas,—as with superheated steam; at others it is a mixture of vapor and particles of liquid, each behaving in a different manner. Fortunately, the entropy diagram so simplifies these calculations that no knowledge of thermodynamics is necessary except the definitions of B.t.u., superheated, saturated and moist steam. The Mollier diagram gives the complete characteristics of steam in all states with which we are concerned. Knowing the superheat, or moisture and pressure, the B.t.u. above 32 deg. fahr., and entropy, can be found. It is not necessary to define or understand entropy, and very few do. We need merely accept the physicist's statement that the *ideal* expansion of steam is along a constant entropy line; that is, vertically downwards on the Mollier diagram. He further tells us that the maximum heat per pound of steam that can be converted into work is the difference between the B.t.u. at the top and the bottom of this vertical line. For example: Steam at 200 lb. absolute, and 100 deg. superheat, has a heat content of 1,258 B.t.u., and an entropy of 1.613. If this is expanded in a perfect engine to atmospheric pressure at the same entropy, the heat remaining in the steam will be 1060 B.t.u.; the difference, 198 B.t.u., will be converted into work. The Mollier chart also tells us that the steam will contain 9.6 per cent moisture. Since a kilowatt hour is equal to 3415 B.t.u., this particular steam engine would require 17.1 lb. of steam per kw.hr.

Such a performance represents the ideal known as the Rankine cycle. No designer has yet reached this perfection, and we rate the performance of a prime mover in the percentage of perfection based on this cycle. If our engine or turbine has a Rankine efficiency ratio of 50 per cent, then only one-half, or 99 B.t.u., is converted into work, and the steam per kw.-hr. is doubled. If the R.E.R. is 66⅔ per cent, 132 B.t.u. is utilized, and the water rate is increased 50 per cent. At this R.E.R., the steam loses only 132 B.t.u., hence the content of the exhaust is 1258 − 132 = 1126. The intersection of the B.t.u. (horizontal line) with the atmospheric pressure line, shows 2.7 per cent moisture instead of the 9.6 per cent.

Strictly speaking, the Rankine efficiency ratio applies only to indicated horsepower, but we have become accustomed to including the mechanical and electrical losses, and in this article it is so used. It varies with the size and design of the engine or turbine. The larger turbines have an R.E.R. of close to 80 per cent, and many small ones only 40 per cent. The unaflow engine varies less widely, possibly because the range in size is not so great, and for low back pressures may be taken for estimating purposes as from 67 to 70 per cent. There is little information available for the engine with high back pressures, but the R.E.R. is probably between 65 and 67 per cent. Fortunately, for a preliminary study to determine the correct operating pressure, an exact ratio is not necessary. Detailed calculations can be made after guarantees have been made by the manufacturer.

Turbines of industrial sizes will have an R.E.R. of 65 to 70 per cent, except for high back pressures, when rotation losses will bring the figure down to as low as 55 per cent in extreme cases.

With these few principles in mind, we may proceed with the discussion of power generation by high pressure steam.

High pressures were used first in large central stations because it was the only forward step left to the designing engineer. Metals now commercially available begin to lose certain of their mechanical properties at about 750 deg. fahr. Steam at 300 lb. had been superheated to this temperature, and engineers in this country did not care to go higher. An increase in pressure offered a new hope of economy, which has been justified, but it also offered difficulties. Expansion from 1,000 lb. to 29 in. of vacuum will deliver exhaust steam with over 16 per cent moisture, a veritable rain storm which would very quickly ruin the turbine blades. Consequently, the first expansion is to about 300 or 400 lb.; then the steam returns to a heating unit to be reheated, or resuperheated, and expansion in this state results in reasonably dry steam, and low turbine maintenance.

The volume of steam at 1,000 lb. pressure is two tenths of the volume at 200 lb. With large powers these volumes are sufficiently large to offer few difficulties, but for small quantities the size of the turbine nozzles become almost minute, and the designer has great difficulty in obtaining a high R.E.R. At present, therefore, pressures of 1,000 lb. and upward are confined to large power units. There has not yet been sufficient demand for small units to stimulate the designers' efforts. This may be a field for the steam engine; at present it is only an interesting speculation.

The small power user owes a debt of gratitude to the electric utility for he now has available not only boilers for higher pressures, but better built boilers for lower pressures; but he cannot make use of higher pressures in the same way as does the central station. It is hopeless for him to compete with the central station unless he can use the exhaust steam in his manufacturing process. Many industrial plants can now generate electric power as a by-product of the process steam, and such power can be produced for a total cost, including fixed charges, of five mills or less, depending upon load factors.

The problem is a very complicated one, and cannot be solved except by detailed study. The accompanying curves, however, may help to explain broadly the manner of attacking the problem and aid in making a rough preliminary study. There

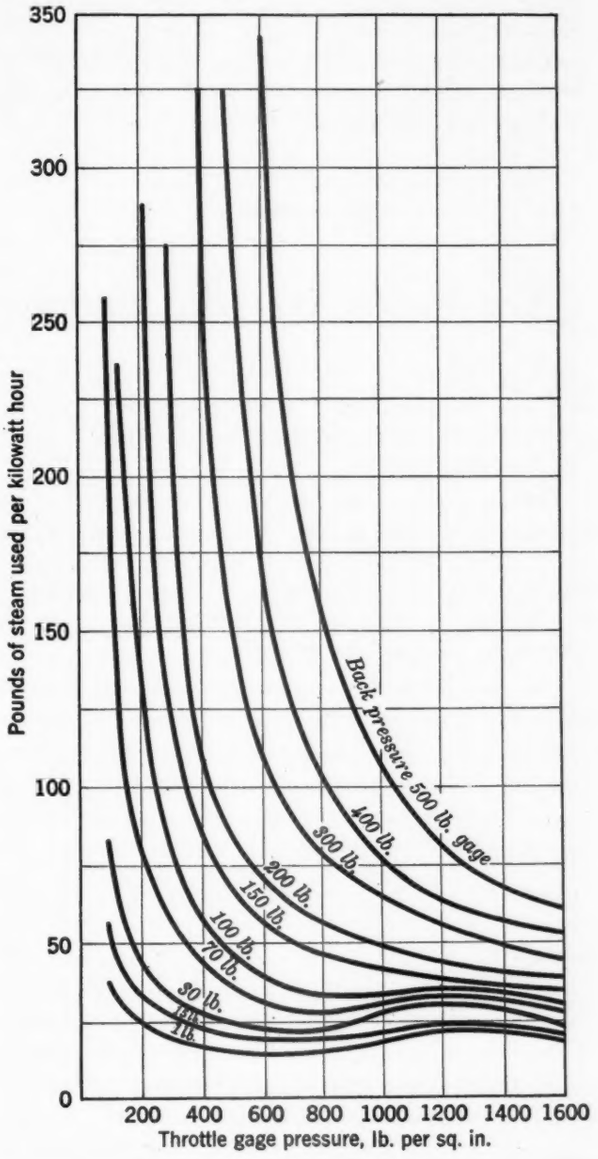


Fig. 1. Curves of relation between throttle pressure and quantity of process steam available from prime mover at varying back pressures

is no short cut to the solution, not even by copying a neighbor's successful plant.

Steam used by a process must generally be neither superheated nor wet. Consequently, if exhaust steam is to be used, the steam discharged by the prime mover should be at or near the saturation point. Superheat at the throttle will reduce the moisture, but too much will give superheat in the exhaust. It is consequently important that not only the pressure, but also the correct preheat, be chosen.

The correct operating pressure and superheat for an industrial plant is that which will supply the necessary electric power without the generation of more steam than that necessary for the process, and at the same time deliver exhaust steam that is commercially dry. The kilowatts that can be generated per 1,000 lb. of steam, increase with an increase of throttle pressure and with a decrease of back pressure or process steam pressure. The B.t.u. per kw.-hr. required for such power is determined by the following formula:

$$\text{B.t.u. per kw.-hr.} = \frac{3415}{\text{Mechanical Effy.} \times \text{Generator Effy.} \times \text{Boiler Effy.}}$$

Mechanical efficiency varies from 95 to 98½ per cent, generator efficiency from 90 to 96 per cent, and boiler efficiency from 65 to 85 per cent. Hence such by-product power can be obtained for a heat expenditure of from 4250 to 6120 B.t.u. per kw.-hr., that is, from 0.33 to 0.47 lb. of average coal per kw.-hr.

The throttle pressure in no way affects the fuel consumption. 1200 lb. operation shows no higher fuel economy than 200 lb. operation. The pressures determine only the number of kilowatts that can be obtained per 1,000 lb. of steam per hr.

To illustrate this, the curves of Figs. 1 and 2 have been prepared. They apply only to by-product power and are for varying superheats, so chosen that the exhaust in all cases will have not greater than 10 deg. superheat, nor 1.0 per cent moisture. Fig. 1 gives the pounds of steam per kw.-hr. that may be expected of turbines or engines for varying throttle pressures and back pressures. Fig. 2 is a chart of power, in kilowatts, that can be obtained for similar pressures.

The total heat of saturated steam is a maximum at about 450 lb. This characteristic gives the low back pressure curves a decided hump at about 800 lb. throttle pressure. This fact is at present merely an interesting detail for it is not thought desirable to use such pressures in a single unit until further development work on turbines and engines has been accomplished.

As an example, in the use of Fig. 2, let us assume a plant requiring 100,000 lb. of steam per hour at a pressure of 100 lb. gage, and at the same time requiring 2,000 kw. of electric power, that is, each 1,000 lb. must generate 20 kw., the intersection of the 100 lb. back pressure curve and the 20 kw. line is at 430 lb. throttle pressure. This is the minimum initial pressure if all power can be generated as a by-product.

If 3,000 kw. are required, it would be necessary to employ 800 lb. pressure, but if only 1,000 kw. were needed, 230 lb. would be ample.

The high back pressures demanded by industrial plants may be so modified by changes in piping sizes or increase in heating surface and proper drainage,

as often to permit of lowering the back pressure. The 230 lb. plant just referred to would generate 1500 kw. instead of 1000 kw. without an increase in boiler pressure, if the steam for process work could be exhausted from the prime mover at 70 lb. instead of 100 lb. back pressure. To retain the 100 lb. back pressure and generate 1,500 kw. would require an increase of throttle pressure to 330 lb. In this case, 30 lb. reduction in back pressure is equivalent to 100 lb. increase in boiler pressure.

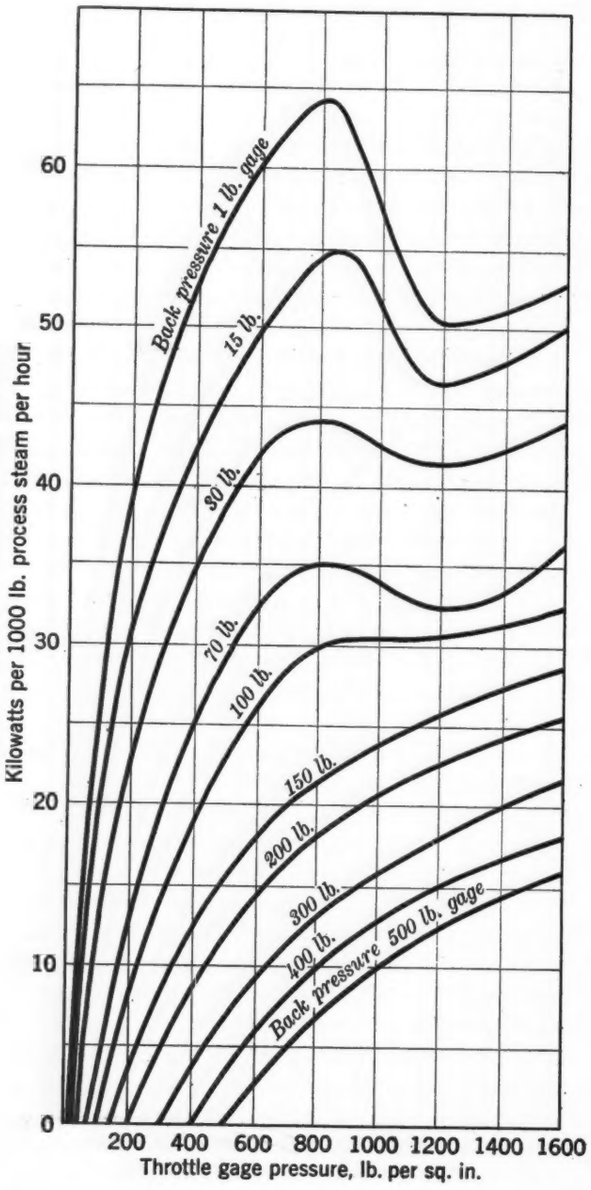


Fig. 2. Curves showing the kw. of power obtainable at varying throttle and back pressures

Many industries now considering an increase in boiler pressure can obtain the same advantages by a reduction in back pressure, with the advantage of lower cost boilers.

The first step in the design of an industrial power plant should be that of determining the minimum pressure that the process can use. When this is determined, the boiler and throttle pressures can be selected. The plants using large quantities of steam and low electric power loads will continue to use low pressure boilers. Those using high pressure process steam, or having large power requirements, must use high pressure boilers. Such boilers are now commercially available, and as the public demand increases, turbines and engines will be developed for high pressure industrial service.

New Values from Big Business

BIG business is a watchword. The high speed activities of today demand for their success a coordination of effort never before considered in this old world of ours.

Debate is rife as to the social consequences of this trend. It is held to be capitalistic, communistic, wise, dangerous, ad lib., but it is always referred to as a fact of the times. For the most part, the man in the street, as well as the philosopher, is rather cheerfully making the best of it.

No business seems immune; perhaps none would rather be immune. Big business requires big men, and who of us does not aspire to climb the ladder of success? Who among us does not think that, given opportunity, he is competent to do better things, and places his limitations at a distance?

In each line the achievement of big business is due to vision, energy and organization. Each line has its leaders and its competitors. Each line has developed its Colossi, probably more from the urge of creative spirit than from the desire merely to make money.

Due largely to the modern perfection of communication, the opportunities for creating big business are today far greater than ever in the world's history. Given the opportunity, men were sure to leap forward with all the requirements for leadership.

The wars of history are records of organization under leadership. There was not much of large scale accomplishment by compact bodies of men other than warfare.

Today's story is the organization of vast bodies of men for industrial objectives under similar leadership. But the result is diametrically opposite. This concerted effort of today does not sacrifice lives, subjugate nations, and destroy values. Instead, it offers increased livelihood for thousands, it renders individuals, groups and nations economically independent, and it creates those enormous new values that spell Civilization.

Upper Drums *of* Large Modern Boilers Require Special Supports

By R. C. Denny, *Technical Editor*

THE forces acting on long steam drums of large high pressure boilers, may reach such values as to cause serious deflection of the drums. If in the field, there is evidence from excessive leakage of tubes at the rolled joints and from steam connections warped out of alignment, that the boiler steam drum has undergone deflection, then immediate investigation should be made. Careful measurements will show the amount of deflection, and proper calculation will determine the fibre stress in the metal of the drum.

Engineering resource is often heavily taxed when coping with increased sizes of equipment. The problems of ordinary sizes are commonplace, and well comprehended. Increasing the size may easily introduce new problems, which is exactly the case with the long, heavy drums required for large modern boilers. One of these problems is discussed in this article.

The upper drums of large boilers are heavily loaded beams; loaded by the weight of tubes and attached lower drums, by the weight of the water contained in the unit, and by their own considerable weight. Suspension has customarily been near the two ends of the drums, with hangers, or their equivalent, located outside of the heat zones. Boilers of moderate size have long had an adequate margin of safety with the result that the fibre stresses in the drum were well within allowable limits, but larger boilers, more recently placed in service, may in some instances have been designed, built and installed without sufficient analysis of the stresses set up by the beam action of their upper drums.

The higher steam pressures, so common in modern practice, require drums having a thickness of the order of 5 in. or 6 in. A drum of this thickness, with an outside diameter of about 54 in. and an over all length of some 40 ft., is not an ideal beam for supporting even its own weight without appreciable deflection. When the drum wall is perforated with several hundred tube holes, a majority of them in the lower half of the section, the area of the metal remaining for withstanding the tension stresses is seriously reduced. Add to this the necessity for maintaining its rigidity as an element of a steam boiler, under conditions of heat due to the steam temperature at the working pressure; then consider the weight of the tubes, the lower drums and the water; and it is reasonable to suspect that the fibre stress is often close to the creep point of the metal. Such may actually be the case.

On account of prohibitive cost, the solution may not, as a rule, be found in thickening the walls of the steam drum. Nor is it a solution to secure additional ligament area by spacing the tubes further apart, because the tube surface thus taken out must be restored to the boiler elsewhere, with the probability of another drum and again a prohibitive cost.

Intermediate drum supports have proved to be a practical solution and are within allowable limits of cost. Such supports must be so disposed as not to be subject to over-heating by the furnace gases. It may be possible to use a modification of the simple U hanger for the intermediate support of drums which are so located that the furnace gases sweeping them have a temperature not higher than 600 or 700 deg. fahr. But for drums in contact with gases in the first pass of the boiler, and consequently at a much higher temperature than 700 deg. fahr., the U hanger is completely out of the question.

For drums so located, the hanger must be attached to the drum above or outside of the high temperature zone, by some style of attached lug.

There is an element of danger in any design which provides for rigid suspension of the drums at three, or more, points. The hangers themselves may not expand in equal amounts, and the three point suspension may, under conditions of operation, become a two point suspension, with a result of imposing exactly the strains that it is intended to prevent. In order to eliminate this danger, the spring type of suspension is suitable for the intermediate hangers, with provision for adjusting the spring compression so as to prevent excessive fibre stresses in the drum.

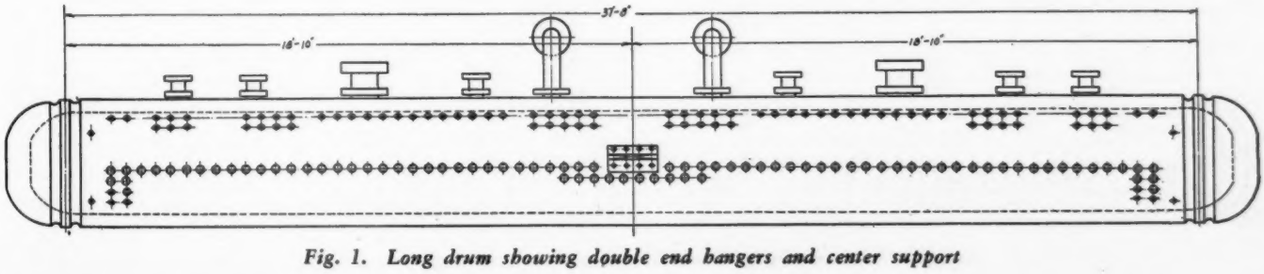


Fig. 1. Long drum showing double end hangers and center support

There is also the possibility that the steel supporting structure, to which the hangers are attached, will furnish the desired resiliency. In such case, it may not be advisable to go to the complication of spring supports.

These intermediate drum suspensions have been satisfactorily worked out, notably in the case of the 1400 lb. pressure boiler recently installed at the Lakeside Station of the Milwaukee Electric Railway

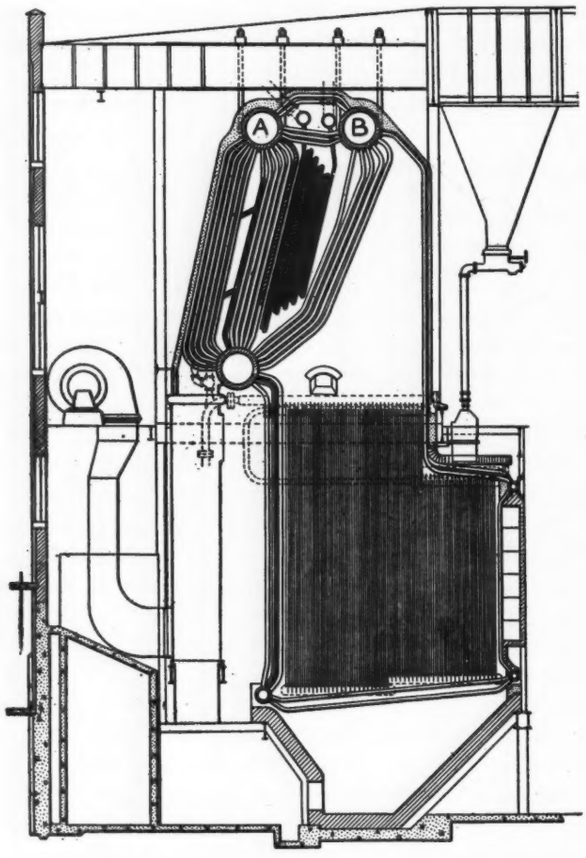


Fig. 2. General arrangement 1400 lb. pressure boiler and furnace at Lakeside Station

and Light Company, and the 500 lb. pressure steam generators now being installed at the East River Station of the New York Edison Company.

The general design of the boiler at Milwaukee is shown in Fig. 2. The steam drum A is 40 in. internal diameter, with walls 5¼ in. thick, and is of forged steel. The outside U hangers are in pairs, each hanger being 4½ in. in diameter, and the two hangers of a pair are spaced 8 in. center to center. Fig. 1 shows the location of these hangers in pairs. The distance between the pairs is 36 ft., 10 in. (measured center to center of inside hanger of each pair).

Drum A, Fig. 2, is subjected to a much heavier loading than drum B, and if no intermediate support were provided for drum A, its fibre stress due to

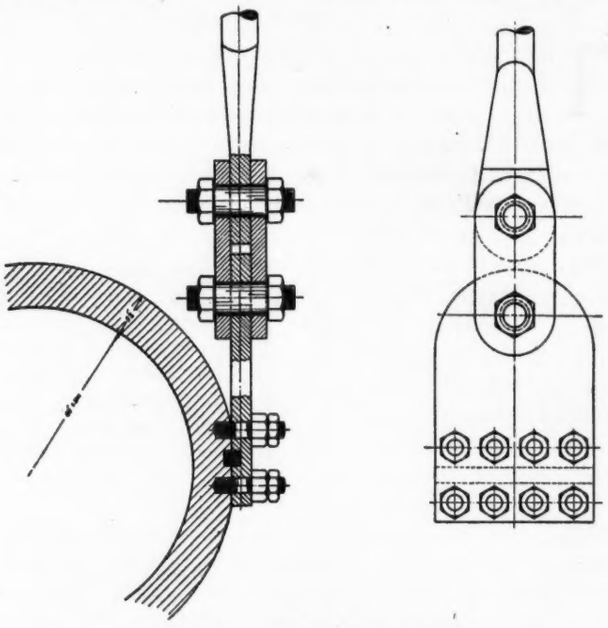


Fig. 3. Method of attaching intermediate drum support

loading would approximate 25,000 lb. per sq. in. This stress is too high for service required, and would allow excessive deflection when new, and seriously increased deflection, due to creep, during the life of the drum. A center support is therefore provided, as shown in Fig. 3. This support transmits a part of the load through its spring suspension, with the result that the maximum fibre stress in the drum will not exceed an allowable 15,000 lb. per sq. in. The forged steel, under the conditions of operation, is thus under reasonable stress, within the A.S.M.E. code limits, and its life should be entirely satisfactory.

Drum B has a much lighter load, and only requires two single end supports to support it safely. This drum is shown in Fig. 4. The U hangers are 4 in. in diameter and are 37 ft., 6 in. center to center.

This unit is designed to produce 250,000 lb. of steam per hour, and has a furnace width of 35 ft.

At the East River Station, two double Ladd type boilers are installed, each designed for a steam production of 800,000 lb. per hour. A vertical half

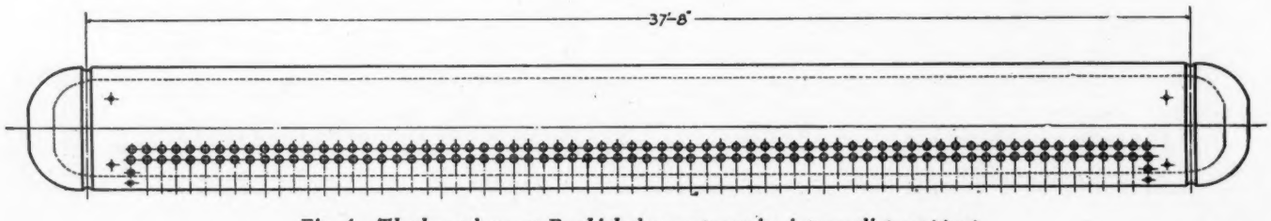


Fig. 4. The long drum at B which does not require intermediate support

section of one of these is shown in Fig. 5. Drum C would be required to carry a load that would over stress the metal unless intermediate drum supports were provided. This drum is 54 in. internal diameter, and has walls 2¼ in. thick. The end hangers are 27 ft. center to center, as shown in Fig. 6. Without intermediate supports the fibre stress would be about 20,000 lb. per square in., but with two intermediate hangers it is reduced to about 8,000 lb., which is a safe allowable stress for the steel used, and for the working conditions.

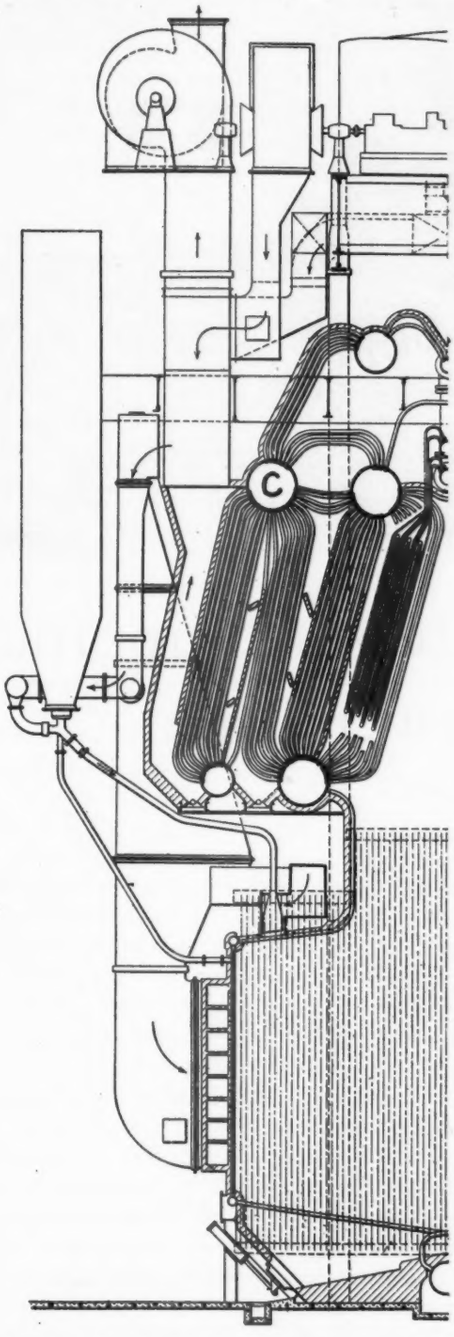


Fig. 5. Sectional elevation of steam generator at East River Station, showing one-half of unit

Since Drum C is located, not in the first pass, but in the third pass, of the gases, the U hangers are permissible. The U bolts are protected from the action of the gases by cast iron protector sections,

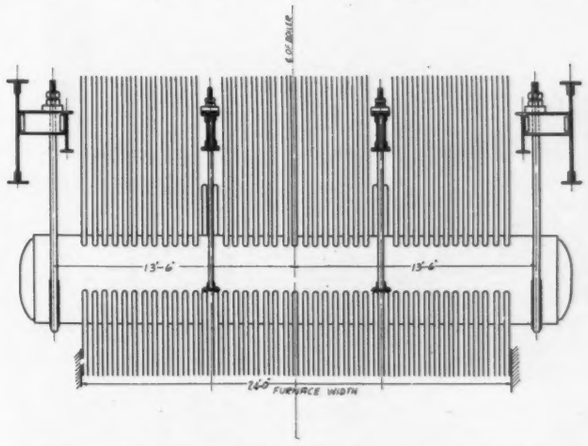


Fig. 6. Location of Intermediate Supports for Drum C

as shown in Fig. 7. There is also considerable protective cooling for the hangers due to the heat absorbed by the rows of tubes on either side of each hanger.

It is clear that, in large modern boilers, the design of these upper drums is more of a problem than merely to satisfy the requirements of strength for the specified steam pressure. Even a further consideration of the creep tendency of steels at the higher steam temperatures, does not cover all of the essentials. The problem must also include a complete examination of the drum as a beam supporting a heavy load, and the methods of the structural steel designer must be used in addition to the methods heretofore common in boiler design. The object of this complete study of the drum is to determine the value of the maximum fibre stress in the steel of the drum, due to any one of the individual loads, and to a combination of all of them. For boilers installed in the United States, the maximum allowable stress is one-fifth of the ultimate tensile strength of the steel used. This allowable stress may be secured at reasonable cost by the use of proper intermediate drum supports.

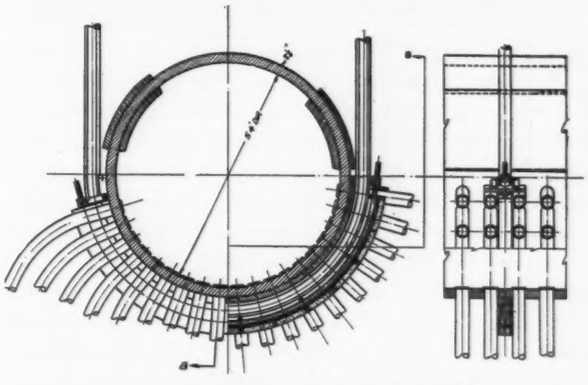
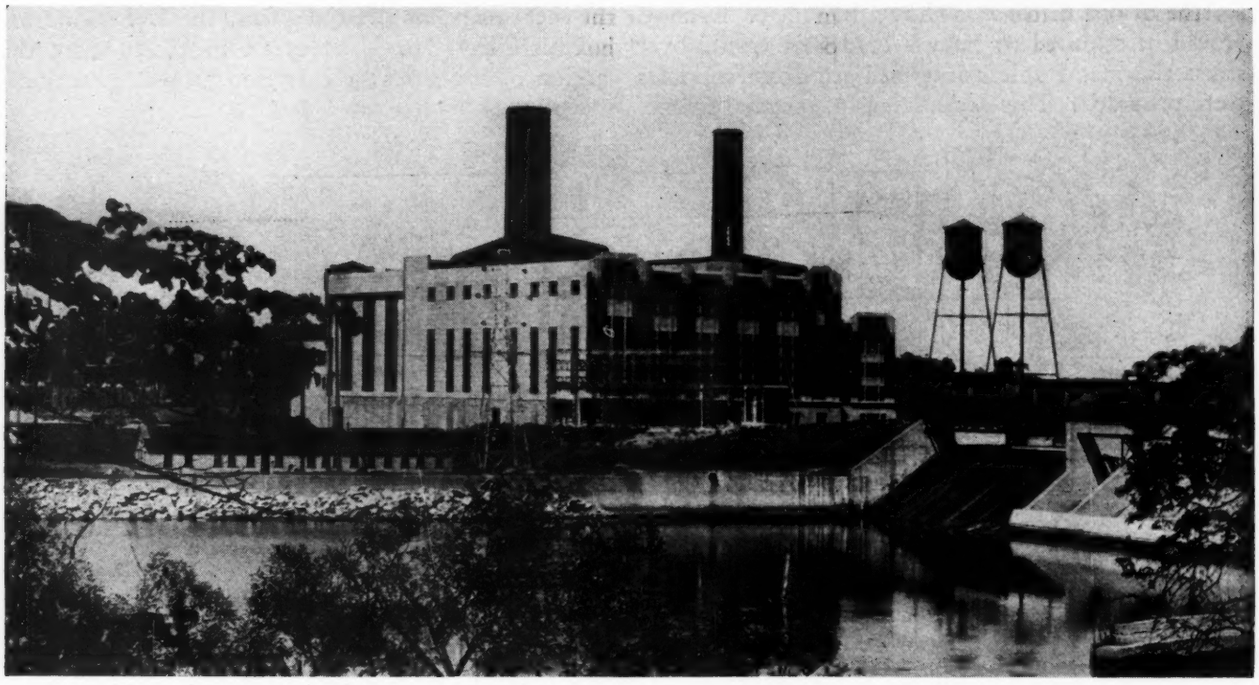


Fig. 7. Detail of Supports for Drum C



Personnel—a Factor *of* Increasing Importance *in the* Modern Power Plant

By Roger D. DeWolf

Rochester Gas and Electric Corporation

NOT so very many years ago, our power plant operators were living in the midst of the soot and coal dust age, when the ability of a fireman was measured by the amount of coal he could shovel, the amount of soot he could put up the stack, and the amount of coal dust he could set in circulation in the boiler room and accumulate in liberal quantities on his sweating muscles.

The "Chief" had graduated from this sort of a boiler room and, as an insignia of his new rank, donned a pair of oily overalls which were cleaned only on national holidays. He carried an oil can with a spout four feet long and ruled his domain with a mighty fist. He could expertly slap a crank pin turning 120 r.p.m. and tell within five degrees how hot it was; he could almost infallibly stop an engine off dead center, and could tell by the click which valve was off in a Corliss gear. He kept things running that were ready to fall apart, when it seemed as if they continued to operate only by grace of God and force of habit; and he got out of many a tight hole by main strength and awkwardness.

The highly developed modern power plant could not be successfully operated by the old fashioned type of operator. Power plant development has been a recent and a swift movement. Has the improvement in quality of personnel kept pace, or is it lagging? Do executives in charge understand the need for specialists in their plants? Mr. DeWolf brings this problem out into the light of public discussion.

Today soot is no longer regarded with respect, coal dust is being confined to the inner workings of the firing system, the fireman's muscles no longer sweat copiously, oily overalls are frowned upon, four foot oil cans have disappeared, temperatures are measured by thermometers, and the roar of turbines has displaced the click of the Corliss valves.

What has been the effect of these developments on the power plant personnel? Might is not right any longer, but knowledge *is* power. Apparatus must not only run, but must run efficiently, smoothly and reliably. Breakdowns must be foreseen and prevented and we must prepare for the unexpected so as to limit the seriousness of its effect upon our operation. We have learned that an ounce of prevention is worth a ton of cure. The station superintendent who so maintains his equipment that serious "accidents" rarely occur, is worth a dozen of the kind that is always getting into hot water and getting out again by the skin of his teeth—sometimes.

Most "accidents" occur because somebody had not thought far enough ahead.

Operating methods, which on superficial examination appear to be satisfactory, may in the long run be the cause of serious troubles. These methods must be carefully analyzed, the troubles foreseen, and the operating practice corrected.

We used to delay our repair work as long as possible—it was left for Sundays, holidays and vacations. This was a bit rough on the operators, but they were tough anyhow, otherwise they wouldn't have stuck to the jobs they had. Much repair work was done in a hurry and went bad in a hurry, so the engineer kept chasing himself around the same demoralizing circle. No one ever thought of taking a machine apart merely to inspect it—the Boss said that if you took a machine apart to see if anything was wrong with it, you would certainly see that something was wrong with it. Why waste the time? Let the thing go until you have to do it, trusting to luck that it will run until Saturday night, and then do the job in a hurry.

Today we don't do repair jobs, we do maintenance jobs. There's a difference. To do a repair job, a thing must first either refuse to run, or break down. Most maintenance jobs on the other hand, are done periodically to keep the equipment tuned up to a high point of efficient and reliable operation, and long before it reaches the stage of breakdown. As a result, "accidents" don't occur, the unexpected doesn't happen, and above all, it pays.

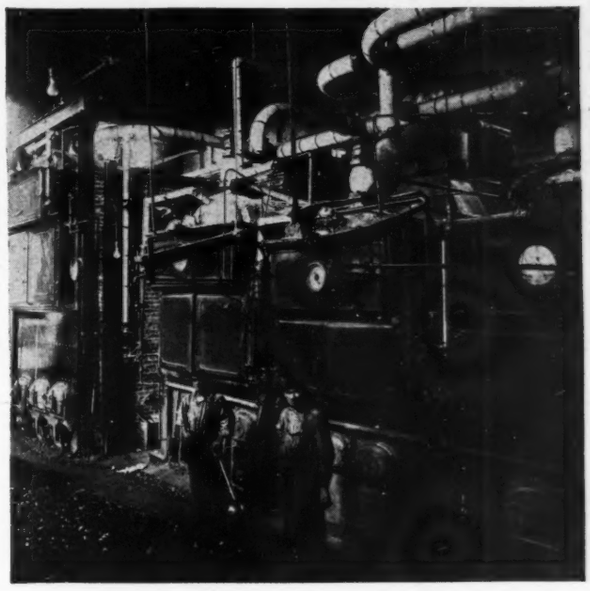
What effect has all this had upon the type of men who make up our power plant personnel? What are the standards by which we measure them? Have these standards changed and has the type of man changed? Are they turned out of the same mould today as yesterday? Are we demanding more things and different things from our station superintendents than formerly?

Technically, there are a great many more things in our stations that some men or some groups of men must know about. They must not only know what the equipment is, but to a very real degree know *why* it is. They must know the inter-relations of the different parts; how those relations can be varied and adjusted, and why a change in one part necessitates a change in another. The man who simply knows that if he makes an adjustment at one point, he must follow it up with an adjustment at another, must be backed up by a man who knows enough of the fundamental theory underlying the operation so that he understands why these inter-related adjustments must be made.

We are today demanding more and more of this technical knowledge from our operators. The man who does certain things simply because he has been told to do them, won't get ahead very fast in competition with the man who, in addition, has studied the basic theory underlying the operation, and has learned the reasons why these things are done.

Last fall, an eminent engineer, just returned from a trip abroad, remarked that after careful comparisons he found that the day in and day out operating efficiency of the American plant was higher and much closer to the best efficiency obtainable under test conditions than is the case with the European plant. Our better plants are being operated on a daily heat balance basis. To accomplish this, we have introduced into our operating organization a new member —sometimes known as the test engineer, sometimes as the results engineer or sometimes by that much maligned title, the efficiency engineer.

The proper term for this new member of our organization is still to be coined, for, in addition to being a technical engineer, he should be a human engineer. The best technician, although capable of testing and analyzing plant results and finding the weak spots, will fail to produce the desired improvement in operation unless he can pass his information on to the regular operators, and teach them how to correct the poor conditions. To do this he must gain their confidence in his leadership. He must not let his theory run away with his nicely balanced sense of the practical, or he becomes a "high brow"; nor must he let the idea of the man who, lacking theoretical training, is wholly dependent upon practical experience, over-ride his own idea which he knows to be theoretically correct.



Typical boiler room of the old fashioned power plant

The plant superintendent and his immediate assistants are today assuming responsibilities tremendously wider and more varied than those of the old "Chief" with his four foot oil can. The "Chief" was expected to keep things running; nothing much more was expected of him. The costs of operation were figures sacred to the "Higher Ups" and were none of his business. Today, the superintendent is not only expected to know all the technical features of his plant, but every detail of the costs of operation

as well. He is expected to know the personal characteristics of the men under him, and by a process of selection, build up an organization with the real spirit of cooperative team work. He initiates many of the changes in plant equipment, lays out the schedule for much of the routine inspection and maintenance, and is generally responsible for keeping his plant in first class condition.

In the old days, the operating engineers and firemen did their own repair work. Today our maintenance men do all this and a great deal more. With the adoption of automatic combustion control systems, feed water regulators, feed water purification systems, and other automatic systems of various kinds, there has come a demand for men who are specialists in these things—in their operation and in the adjustments and maintenance required to keep them in satisfactory operating condition. These men, under the guidance of the superintendent, furnish the ounce of prevention that is becoming so effective.

Operating floor in modern pulverized fuel fired plant, illustrating neatness and instrument control

Our power plant organizations, under the superintendents and their direct assistants, have therefore become regularly organized into two distinct sections, the regular operators and the maintenance crew. They are somewhat like the modern machine shop equipped with automatic and semi-automatic machine tools, where the operators of these tools are expected to turn out volume production and the inspection crew is expected to keep the tools in proper condition to turn out the accurate work in large volume. In just this way, station operators are expected to turn out the kilowatt hours, adjusting their operating conditions to meet the load conditions and maintaining a high operating efficiency at all times, while the maintenance men assume the responsibility for keeping the apparatus in first class condition. The operators have become specialists in their line of work, and the maintenance men in theirs.

With the adoption of new and larger equipment—new automatic devices, and new heat cycles, the operators have many new problems to meet. In handling some of these problems, experience with the old type of apparatus may be of little or no value may, indeed, be a hindrance rather than a help. It is sometimes harder to "unlearn" an old time operator than to break in a raw recruit. Men whose ideas are fixed by experience gained ten years ago, are likely to absorb new ideas slowly and with considerable difficulty. The art has been changing so rapidly, and so many new principles have been incorporated, that things don't work the way the old time operator thinks they should. It was an old time operator who concluded that the new fangled steam flow meter was "no good" because its indicating hand went up as the steam gauge hand went down. They were both on the same boiler, he argued, and on the same steam, and therefore they should both go up and down together.

The adoption of the various types of automatic controls has given us new problems. When operating properly, they can give us a higher efficiency and a quicker response to changing load conditions than we can expect from any average operator. But they don't all operate properly, and none of them operates properly at all times because they are mechanisms and subject to wear. The operator must understand these controls thoroughly so as to be able to make the necessary adjustments to correct for their faulty operation, or to secure proper operation under abnormal conditions. He must also know how to handle his equipment with the automatic control thrown entirely out of commission, in other words, reverting back to hand operation. Ability to use his head under all conditions of operation is a most necessary asset of the operator today.

And what a difference there is between the maintenance job and the old type of repair job. Today we make periodic inspections, minor replacements and adjustments, at times when we can conveniently take the apparatus out of commission, rather than wait until it breaks down so that we have to do the work at a time when we need the machine. This new procedure forms one of the basic changes in our operating methods. The maintenance men must be skilled in taking down and reassembling the equipment, in properly adjusting it and testing it out, and in judging just how far wear in a certain part may be permitted to go without necessitating replacement. Oftentimes, by making minor changes, these men can improve a machine's operation, or its reliability. They may be called upon to determine the cause of trouble when the operator has been unable to locate it. This work is absolutely fundamental, and, here again, it is evident that the man who uses his head is the man worth while.

Today it is more necessary than ever before that the entire operating organization shall cooperate in order to attain the best results. The men on one shift must carry on their operation so that the plant will be in efficient condition to meet the loads it will have to carry during the next shift. The operators and the maintenance men must exchange ideas and experiences regarding troubles with the equipment and the most effective methods for correcting them, and must discuss these matters with the superintendent and his direct assistants.

In the foregoing, an attempt has been made to discuss more or less briefly the changes that have taken place during the past two decades in power plant personnel, and the principles toward which our present day personnel should strive. Human ambitions, jealousies and short-comings, combine with the defects of equipment and the general cussedness of nature to make the attainment of these aims difficult; but it is only by earnestly striving toward such aims and purposes that we can hope to build up a real power plant personnel.

Errors in the Measurement of the Temperature of Flue Gases

Digest of paper by P. Nicholls and W. E. Rice, delivered at the Semi-Annual Meeting of the American Society of Heating and Ventilating Engineers, at Bigwin Inn, Lake-of-Bays, Ontario, Canada

THE object of the paper is to examine the errors in thermocouple measurement due to its failure to register the true temperature of the gas stream. Numerous tests were made, the most satisfactory of which were in a 30 in. flue.

Approximate Temperature	Exposed Thermocouples		Shielded Thermo-Couple Between 1 and 2	Metal Surface	Approximate Error of Exposed Thermo-Couple
	1	2			
400	395	388	402	348	10
500	475	470	482	406	15
600	596	593	607	520	13
700	712	711	725	576	16

Table 1

Both shielded thermocouples, as shown in Fig. 1, and unshielded thermocouples, were used, and set up in a 30 in. flue as indicated in Fig. 2. The results are given in Table 1. The authors conclude that:

"Although a thermocouple in the center of the flue indicates a temperature lower than the true temperature of the gas in contact with it, yet this lower value will not differ much from the true average temperature of the gas in the flue because the temperature of the gas in the center of the flue is higher than the average over the cross section.

"The tests here reported have therefore shown that the use of an exposed thermocouple installed as specified by the Boiler Testing Code of the Society, and with the flue insulated, will indicate a temperature which will approach that of the true average temperature of the gases. The probable error should be within 10 degrees.

"It is suggested that a standardization of the position of the thermocouple for test purposes should be with its junction on the center line of the flue. The best location would be at 4 equivalent flue diameters from the boiler because this would give time for the gases to mix; this might not always be convenient and it would be satisfactory to allow not less than 2 or more than 4 diameters. The size of the thermocouple wire should not be more than No. 20 B and S gauge (0.0319)."

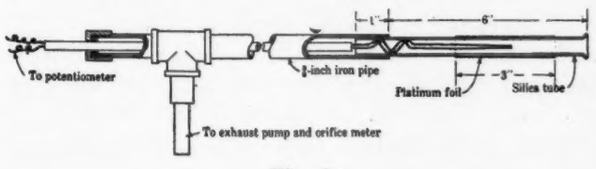


Fig. 1

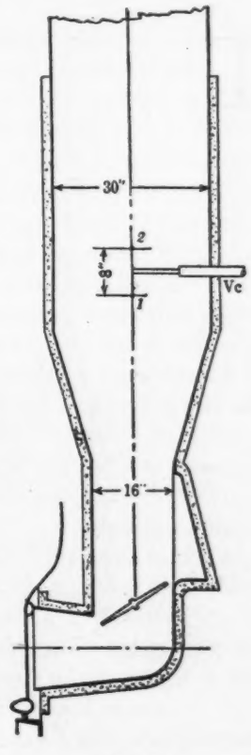
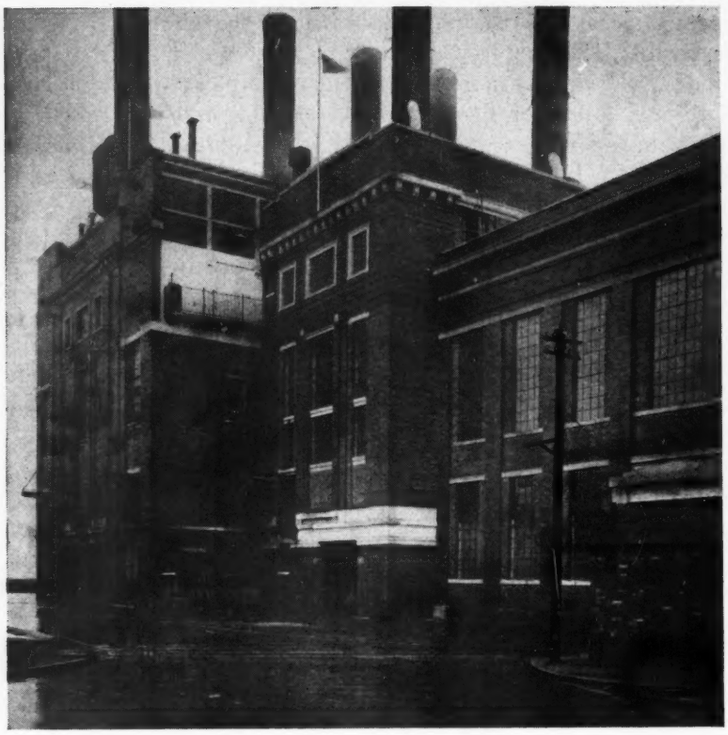


Fig. 2



Super power development in Great Britain is apparently proceeding in an orderly manner. The entire country is to be divided into four major divisions, and transmission line structure will be standardized. There has already been a rapid development in power station equipment, so that interconnection is the next logical step toward the super power system.

Barton Power Station at Manchester, England, designed for 150,000 k.w. ultimate capacity.

Power Station Practice *in* Great Britain

A Complicated and Rapidly Changing Situation

By David Brownlie, London

THE present general position in the British power station world is difficult to sum up in a few words. The salient feature is the change-over that is gradually being made to the generation of electricity in a relatively limited number of large and efficient power stations, in place of a scattered multitude of small stations, and the consequent rapid growth of overhead high tension transmission lines.

For example, as shown by the first Annual Report of the Central Electricity Board, published in May 1929, there has been set up by the Board from the 1st March 1927 to the 1st December 1928, four main schemes for co-ordinated electricity supply, that is Central Scotland, South-East England, Central England, and North-West England and North Wales, while there has since also been adopted the Mid-East England scheme.

As regards the actual transmission it has now been decided to use 132,000 volts for the primary lines, which is finally regarded as the best net figure for the particular conditions in Great Britain while also in all cases the maximum span is being used, with steel cored aluminum conductors. It must be remembered that Great Britain is not only a relatively small country but that it has also a very long history, so that considerable difficulties have arisen for example, in connection with rights of way and the consent to use overhead transmission lines. Incidentally, the chaos in London's electricity supply, with about 70 different authorities concerned, is partly due to similar complications, added to those caused by the use of electricity from about 1880.

In Great Britain the average height of the steel towers is now to be 70 feet for single circuit lines and 80 feet for double circuit lines, with a minimum span of 900 feet, that is about six towers to the mile. However, there are naturally many variations from these standards according to the local circumstances, of which an example is the crossing of the River Clyde and also the River Forth, in which connection the towers vary from 200 to 238 feet in height, and in one instance over the Forth the span is 3050 feet, using special conductors composed of 19 strands of galvanized wire, each 0.125 in. diameter, with 18 aluminum strands of the same diameter.

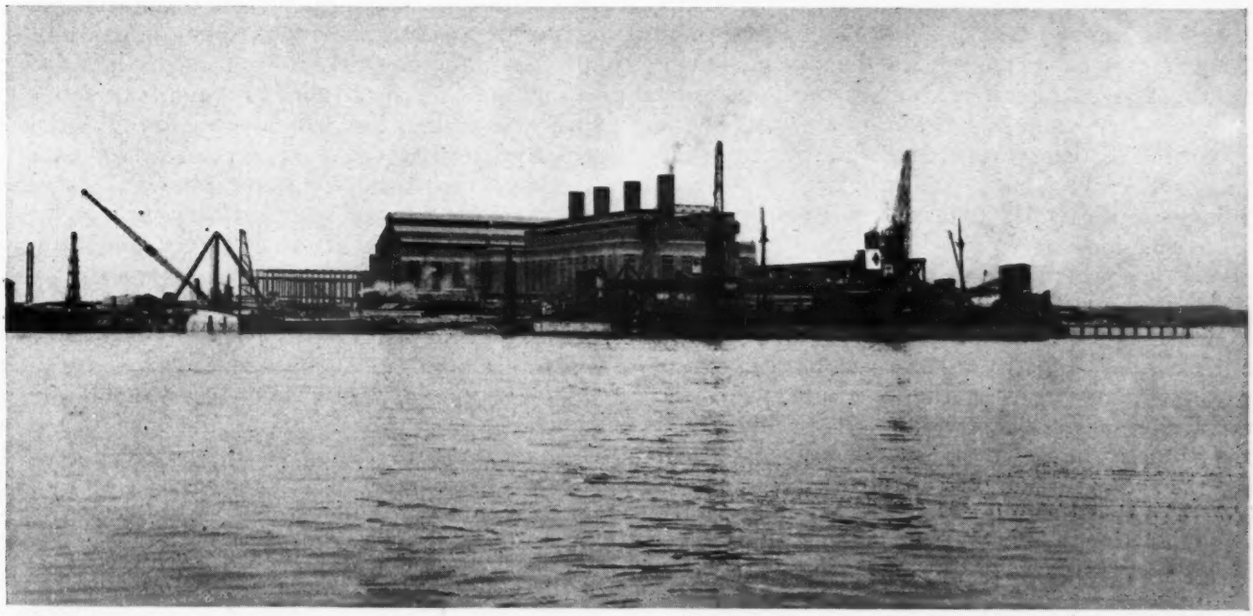
In general Great Britain is backward from the point of view of the amount of electricity consumed per capita, but the circumstances are peculiar, and there is likely to be a considerable improvement in this respect during the next few years.

The status of steam generation and fuel technology is of definite interest. It may be stated that there are in the United Kingdom (Great Britain and Ireland) 570 generating stations, with a production for example of 9,927,850,630 units in the year 1927-28, that is according to the Electricity Commissioners' Report for the year ending 31st March 1928, while the corresponding total fuel consumption—coal, coke and oil—amounted to 9,224,151 tons, of which 9,177,594 tons was coal, corresponding to 95.7 per cent of the electricity generated. The other items are therefore negligible, being 0.63 per cent from oil engine stations, 0.19 per cent from gas producer stations, 2.19 per cent waste heat, 0.21 per cent refuse destructors, 0.03 per cent from gas engines using towns gas, and 1.05 per cent from water power.

Incidentally it may be mentioned that Great Britain has only about 1,000,000 hp. of potential inland water power, of which approximately 250,000 hp. is in operation, largely however used by private concerns and not by electricity supply companies. A notable exception is the North Wales Power Company, Ltd., which has just completed its small Maentwrog Hydro-Electric installation in North Wales with 18,000 kw. capacity. However, Great Britain has one important asset not yet developed; that is the "bore" of the River Severn, which has an average tide of over 40 feet and represents about 500,000 hp., while there are probably other areas in the country that could be developed, such as the Walney Channel at Barrow for the utilization of the sea for the generation of electricity according to well-known lines, quite apart from any results that may develop from the research work now being carried out in France in relation to tidal power.

With regard to the size of power stations in Great Britain there are about nine stations generating over 200,000,000 units per annum, while eleven stations are between 100,000,000 to 200,000,000 units, and thirty-two stations between 50,000,000 and 100,000,000 units. The largest power Stations of over 200,000,000 units are Barking (County of London Electric Supply Co., Ltd.), Dalmarnock (Glasgow Corporation), Lister Drive (Liverpool Corporation), Greenwich (London County Council Tramways), Lots Road (County of London Electric Supply Co., Ltd.), Barton (Manchester Corporation), Carville (Newcastle-on-Tyne Electric Supply Co.), North Tees (Newcastle-on-Tyne Electric Supply Co., Ltd.), and Princes (Birmingham Corporation). Also a number of new large stations are projected, as well as considerable extensions to existing plants, particularly Barking on the Thames, which has now an installed capacity of approximately 200,000 kw. and will be extended to 300,000 kw., with plant—it is stated—ultimately for 600,000 kw.

Apart, however, from the advent of the super-power station in Great Britain, a more or less complete revolution is also being carried out as regards steam generation practice, and particularly since the introduction of pulverized fuel firing only about five years ago. For example, the following important stations are already equipped, either partly or wholly, with pulverized fuel firing: Barking (London), Hams Hall (Birmingham), Willesden (London), Derby, Kirkstall (Leeds), Leicester, Poplar (London) and St. Pancras (London), as well as smaller stations and many industrial plants, an astonishing advance



Barking Power Station of the County of London Electric Supply Co., Ltd. This 200,000 k.w. station, now to be extended to 300,000 k.w., is the largest power station in the United Kingdom.

in only about five years. In Great Britain today, as in every industrial country in the world, for any new power station project, pulverized fuel firing is considered as a matter of course.

At the same time Great Britain is undoubtedly well to the fore with mechanical stoking, particularly machines of the traveling grate type. For example, there is now being constructed to the orders of the London Power Co., Ltd., for their Deptford East Power Station, two "Underfeed Type L" traveling grate stokers no less than 31 ft. 0 in. wide each, having 700 square feet grate area for operating boilers of 200,000 lb. normal evaporation per hour, in conjunction with multiple plate air preheaters to supply air at about 250 deg. fahr., the steam pressure being 525 lb. gauge, with 700 deg. fahr. superheated steam temperature. These are the largest traveling grate stokers in the world, and of course a width of 30 feet or over has only been rendered possible by the introduction in the United States of the suspended firebrick arch, which is now also being rapidly adopted in Great Britain. Curiously enough, the multiple retort stoker has never made much progress in British power station practice, which is largely due to the relatively high ash content of the coal and difficulties in connection with slag formation, inherent in the use of a very deep fuel bed.

The traveling grate stoker is essentially a British invention, primarily that of John Juckes in 1841, although there now seems to be no question, according to the investigations of the author, that Juckes got his ideas from John George Bodmer, a Swiss engineer then resident in Great Britain, who—along with Juckes, William Brunton and John Stanley—is one of the world's great pioneers in the history of mechanical stoking. The matter is still further complicated because it is probable that Bodmer, in turn, based his designs on the traveling "web" or grate type of gas works retort invented about 1815 by Samuel Clegg, the famous pioneer of the towns gas industry. However, from the boiler house point of view Juckes can be regarded as the pioneer in the history of the chain grate or traveling grate stoker, which has probably been more used throughout the world than all the other types of stoker combined.

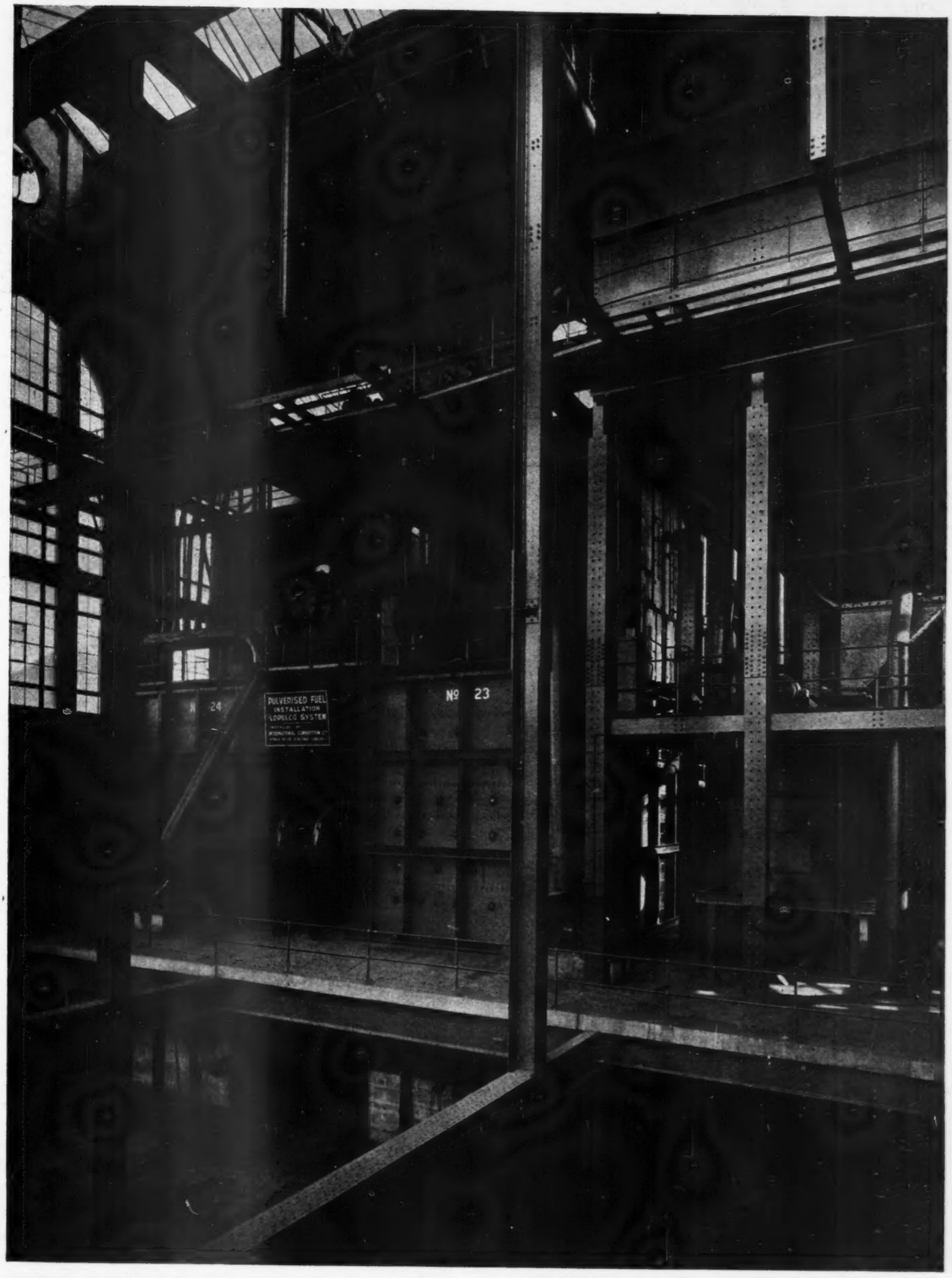
It is of course familiar knowledge that in the United States boilers of 300,000 to 400,000 lb. evaporation per hour are being operated by the multiple retort type of stoker, and here in Great Britain we have reached the stage of 200,000 lb. evaporation with the traveling grate stoker, and this figure is likely to be considerably exceeded. Also the average steam pressure used is beginning to increase so that today less than 350 to 450 lb. gauge would not be considered for any important installation and a number of forged steel drum boilers are under construction for 800 to 1200 lb. pressure, while for a considerable period a steamship "King George V" on the Clyde Service, has been operating with 600 lb. per square inch with forged drum boilers.

Air preheating is also being adopted more and more in British power station practice, but the situation with regard to feed-water economizers is in a state of flux at the moment. The various methods available, that is, air preheating and no feed-water economizers, combined air preheating and economizers, and economizers only, each have their advocates, while there is considerable controversey as to whether the economizer is more suitable in the shape of special high-pressure cast iron designs, steel tubes, or some hybrid principle such as steel tubes with cast iron gills on the outside, operated in conjunction with steam blowers to eliminate the difficulty from the deposition of ash and finely divided material on the exterior surfaces of the tubes.

A very interesting development also in British power practice, which has not yet made much progress in the United States is the treatment of the cooling water with a measured trace of chlorine gas, generally about one part to two million, so as to give complete sterilization and prevent the growth of organic deposits on the condenser tubes. The same method is also available for eliminating trouble caused by the growth of weeds in cooling towers, and for mussels and other shell-fish in the pipe circuits when sea-water or brackish water has to be employed. The action in this case is to kill the minute organisms upon which the shell-fish live, and it is hardly necessary to emphasize that organic deposits upon turbine condenser tubes are apt to be a peculiarly irritating and costly matter, reducing the heat conductivity and therefore the vacuum obtained. A considerable number of power stations in Great Britain are now equipped with chlorine gas apparatus of this description, with highly beneficial results both as regards reducing the steam consumption of the turbines over long periods, and saving in labor due to the fact that it is no longer necessary to clean the condenser tubes by hand.

Finally, over here in London we are already in the throes of a trouble which appears to be spreading throughout the world in connection with power station practice, that is, the acid sulphurous gases discharged from the chimney as a normal constituent in the burning of coal. This has arisen in the shape of an uproar concerning the building of a new power station at Battersea on the Thames, which will ultimately require about 2000 tons of coal per 24 hours. It is pointed out that on a reasonable estimate of an average of 1.5 per cent sulphur in the coal this corresponds to 30 tons of sulphur, or 90 tons calculated as sulphuric acid, discharged from the chimney per twenty-four hours, with disastrous effects in regard to a city like London with over 7,000,000 inhabitants and many public gardens.

This trouble has really started as the result of an allegation that the crops of a farmer in the neighborhood of Manchester have been damaged by the gases



Interior of Derby Power Station, at Derby, England, showing modern steam generators and pulverized fuel equipment.

from the Barton Electricity Station chimneys. This complaint has nothing to do with smoke, grit or dust, but is concerned entirely with invisible sulphur gases, in the form of sulphurous or sulphuric acid. This matter was taken up by the Farmers' Federation, who won the case in the Law Courts

Boiler Room of the Barton Power Station, with 9 boilers, each having a normal capacity of 100,000 lb. steam per hour at 375 lb. pressure and 738 deg. fah. temperature.

against the Manchester Corporation on the first trial, but the decision was reversed on the appeal of the Corporation. Now, finally, the case is in the House of Lords, the final Appeal Court of the United Kingdom, so that what will happen remains to be seen.

It is well known that many prominent power stations in the United States, Trenton Channel, for example, are devoting practical attention to the whole question of the purity of gases at the chimney top. But the part played by sulphur in the matter is only now being realized, and it will undoubtedly soon become one of the inherent problems of power station practice. This problem of the liberation of large quantities of sulphur compounds bids fair to equal in importance the problems of the huge losses in condensing water discharge, and the further problem of retrieving the present enormous waste of by-products that exist in raw coal and that may be obtained by the low temperature carbonization processes.

The author has made the suggestion that all the different electrical power station authorities in London should unite and carry out large scale co-operative research work on this question of the elimination of sulphur in chminey gases, using one of the London power stations for the purpose, but apparently little is going to be done in this connection at the moment. Sooner or later, however, the question of sulphur in chimney gases will have to be tackled, and the problem is admittedly difficult, although theoretically one could wash the whole of the gases by pressure sprays of water.

The situation would be quite changed with the general adoption of low temperature carbonization

The Barton Station Turbine Room showing three 34,375 k.w. Vickers turbo generators.

or total gasification of the coal before combustion in power station practice, since the much smaller volume of gases could be easily treated for the elimination of sulphur, a very different matter from dealing with the huge volume resulting from the combustion of raw coal.

The Refractory Furnace Developed *for* Modern Practice

By R. D. Foltz

M. H. Detrick Company, New York

PRIOR to the application of the pulverized fuel system of burning coal in steam boiler furnaces, the standard construction of furnaces consisted of solid walls lined with fire brick. Such walls did not satisfactorily withstand the destructive action of pulverized fuel firing. Hollow, air-cooled refractory walls and water-cooled walls, were thereupon devised, and both types are extensively used. The general subject of furnace construction is so broad in scope that this article is confined principally to a discussion of the refractory type of furnace.

Notwithstanding the popularity and wide adoption of water cooled walls, the refractory furnace still holds an important position in steam boiler practice. Mr. Foltz not only discusses the limitations of refractories, but also points out how improved furnace construction has raised those limitations of refractory furnaces that were characteristic of the old fashioned solid refractory wall.

Furnaces have increased in size with the increase in size of boilers; in fact, furnaces have grown very much larger in proportion because of the growth in ratings required from boilers. The 600 hp. steam boiler unit of only a little over a decade ago, operating at 200 per cent rating and producing about 36,000 lb. of steam per hour, is completely overshadowed in size by present-day steam generating units that produce over half a million pounds of steam per hour,—and the future demand may be for a million or more pounds per hour per unit. The 600 hp. unit was equipped with about 150 sq. ft. of stoker area, perhaps 12 ft. wide by 12½ ft. long and the setting height may have been 10 ft. Furnace walls roughly 12 ft. long by 10 ft. high were required.

Today stokers are being built in sizes over 500 sq. ft. in area, with side walls in the neighborhood of 20 ft. long, and front and rear walls as much as 24 ft. across. Setting heights have increased to 20 and 25 feet. Furnace walls 20 ft. long by 25 ft. high are required, for such settings and these are quite a different proposition from the older ones. The largest steam generating units are fired today with pulverized coal exclusively, and their furnaces have required walls about 43 ft. long by 70 ft. high. This is all merely on the score of size.

The advent of pulverized coal, as a commercial method of firing, ushered in a new era in combustion. Among other achievements of this new era, was a high skill in burning coal, both in pulverized form and on stokers, with higher CO_2 and lower excess air. The furnace gases were richer and hotter, and the furnaces had to be built to withstand the increased destructive action.

Refractory furnace walls and water cooled walls have both developed satisfactorily in reliability and in particular usefulness. Their limitations, however, are as distinct as are their respective advantages. The case for water-cooled walls is quite thoroughly before the engineering public, and is strongly argued by the fact that the largest of the pulverized fuel furnaces are practically 100 per cent this type of construction. The case for refractory walls is somewhat eclipsed, not for lack of inherent virtues, but because its limitations are rather better known. The really valuable properties of water-cooled walls have created an impression that refractory walls are now a thing of the past, that no enlightened engineer should for a minute consider them, and that all troubles incident to them can now be confidently forgotten. This is the atmosphere that usually surrounds new products; and it is often so rosy an atmosphere as to outshine the solid merits of the older method.

In a general way, it may be stated that stoker furnaces should never be 100 per cent enclosed with water-cooled walls, but that pulverized fuel fired furnaces may be so enclosed. In precisely as general a way, it may also be stated, that, under proper conditions, furnaces for both firing methods may be enclosed with 100 per cent refractory linings.

Impingement, as used in furnace discussion, refers to contact of the flame with surrounding surfaces or with boiler tubes in the path of flame travel. Impingement by furnace flames on refractories is the general source of refractory failure, through erosion. There are two devices for wholly or partly overcoming this erosion. One is to build the furnace large enough and at the same time guide the direction and travel of the flame to eliminate the impingement. The refractories will then be subject only to furnace temperature, and not to erosion. The other device is to cool the refractory furnace lining. This cooling is adequately secured by circulating air over the outside surface of the lining; a method of construction to which the sectionally supported type of refractory wall lends itself admirably.

Instead of eliminating the refractory furnace, the water-cooled wall has stimulated its development and now both are growing side by side, each having

its own field, with lines of demarcation gradually becoming more distinct. In general, the field of the water-cooled furnace is that of the high capacity, high load factor installation, and that of the refractory furnace, the lower capacity, and particularly the low load factor installation. Yet there are exceptions. There are relatively few boiler installations having a capacity as high as 300,000 lb.per hour per unit. The Avon Station of the Cleveland Electric Illuminating Company has four units of this capacity with complete air-cooled refractory walls and water screen. There are a large number of smaller units with equally satisfactory refractory furnaces, operating at capacities ranging from 100,000 to 150,000 lb. per hour.

It will be instructive to examine the characteristics of refractory walls. The history of refractories used for furnace linings is old enough to yield rather definite information. The case for refractories will not be weakened by frankly discussing their well known limitations, since we shall also note how to surmount them in practical furnace construction.

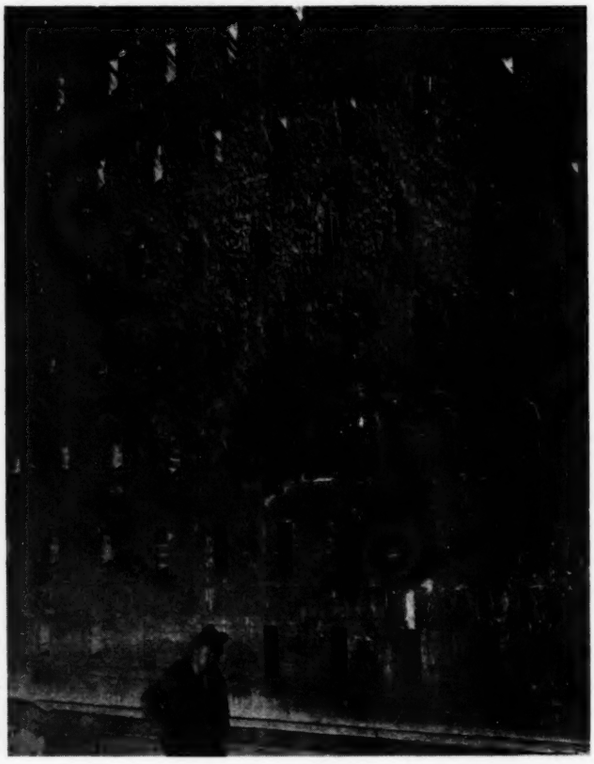
There are five reasons, any one of which may cause the failure of a refractory wall. They are: Melting, softening, spalling, fluxing and expansion. A sixth, structural strength, need not be discussed for any fire brick is strong enough for a furnace wall. The

Furnace for pulverized fuel firing under steam boiler, illustrating the high walls of the modern furnace

first three are functions of brick manufacture, the fourth of coal quality, and the fifth of design. With a complete understanding of these five factors we may design an entirely satisfactory refractory furnace.

Very few cases of failure occur by melting, except in burning oil with extremely low excess air. Such brick as will withstand the resulting temperatures are very expensive and are used only when the furnace size is limited, as for example in the express type of boiler used in Navy destroyers. In such cases the brick lining is thin, 4½ in., and cooling of the brick is obtained by furnace radiation. Many failures that appear to be melting are in fact fluxing, which will be discussed later.

The better grades of fire brick will not melt under any but the most extreme furnace temperatures.

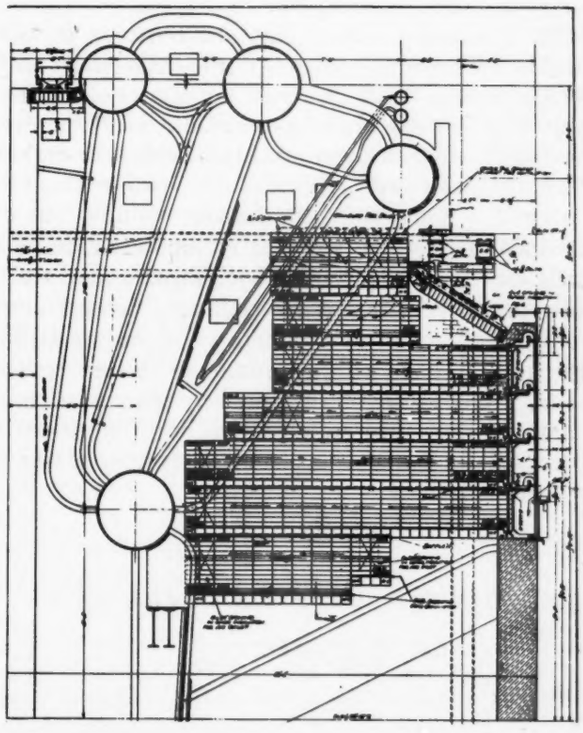


A sectional refractory side wall that has been in service with pulverized fuel firing, showing effect of different temperatures at different heights of wall

Probably no coal burning furnace whether pulverized or stoker fired, operates at a temperature high enough to melt any first quality fire brick, even when the walls are thick and there is little chance for external cooling. We may therefore dismiss this item from further consideration.

Softening is a far more frequent cause for trouble, in fact one of the major causes. Softening occurs at a much lower temperature than does melting; frequently at temperatures much below the maximum furnace temperatures. In a furnace laid up with fire brick, softening near the bottom, where it is usually hottest, will reduce the carrying capacity of the brick. The inner surface of the furnace is hence inadequately supported and gradually leans inward and eventually falls unless frequently repaired.

The relieving arch customary in solid walls is intended to minimize such trouble by relieving the lower courses of fire brick of the great weight of the upper wall. Some furnace walls have been inclined outward from the vertical to prevent them from



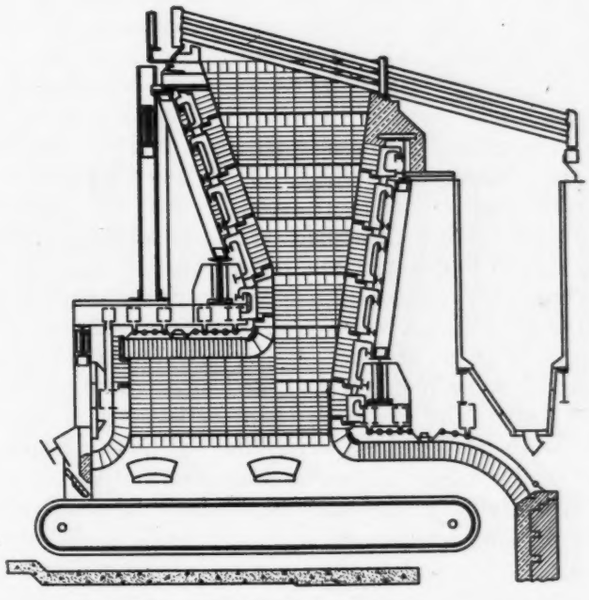
Side wall of sectional construction for the furnace of an underfeed stoker installation

moving past the vertical and falling. Any method of dividing the weight into horizontal sections tends to reduce the trouble from softening.

Air cooling benefits furnace walls by carrying away sufficient heat to keep the inner surface of the brick below the softening temperature. Such walls are, of necessity, thin, because brick has low heat conductivity. A thick wall will not permit sufficient heat flow through the brick to secure an appreciable cooling effect on the inner surface. Probably nine or ten inches is the maximum thickness with which air cooling is effective.

When some refractories are alternately heated and cooled, the expansion and contraction causes a mechanical failure and particles of brick on the heated side fall away, leaving a ragged surface. This action is known as spalling. It is easily recognized because the brick surface has the appearance of having been broken away with a metal tool. The only chance of mistaken diagnosis is when clinker, which has adhered to the wall, has been broken away with an iron. Some of the brick is often carried away leaving a surface similar to that of a spalled brick. With some coals, molten ash adheres to the walls in a thin sheet which on cooling hardens and contracts at a greater rate than the brick, thus shearing off the surface leaving it with a spalled appearance. If the clinker cannot be eliminated by improved firing methods, a brick must be used with greater mechanical strength, or the inner surface must be cooled below the fusing temperature of the ash.

In cases where fire brick flows, it is seldom due to melting but generally because the chemical composition of the ash is such as to act as a flux, and as fast as the ash comes into contact with the brick, fluxing occurs and the brick is washed away. Such an action will continue in some cases until, in spots, less than one brick's thickness remains. If this spot is small and at a point which carries no great wall load, the brick will remain indefinitely without further thinning. This phenomenon is due to the fact that the thin brick can now carry the heat away rapidly, and the inner surface becomes so cool that the fluxing action can no longer continue—the surface is at the temperature at which the ash congeals. Solid ash cannot act as a flux, and the action ceases.



Furnace for traveling grate stoker with all four of the high walls built of sectional refractory construction

Air cooling, except under extreme conditions, corrects this fluxing trouble, and water cooling is always successful. An increase in excess air and consequent lowering of furnace temperature is another remedy if air cooled walls are used, but if solid brick walls are used, so high a percentage of excess air is required that the resulting stack loss is excessively high and the boiler efficiency correspondingly low.

With the best of fire brick, the coefficient of expansion, although very low, is a factor that must be provided for. Fire brick is usually laid up in thin fire clay. This clay does not form a bond but rather

a bearing surface and gas seal. The bond is caused by the frictional resistance of the brick surfaces, and this resistance is large because of the heavy weight of the upper courses. From an expansion standpoint the wall is a monolith because the bricks cannot move individually. Expansion joints must, therefore, be provided. Many types have been designed, each meeting with indifferent success, and this is particularly true of built up air cooled walls. The bonds between inner and outer walls have usually been of special tile. Since the inner or furnace wall has been substantially monolithic, its slight expansion movement near the top has been sufficient to fracture the bonding tile, letting the thin wall fall inward. Had it been possible to support the inner wall in short horizontal sections, the expansion of each section would not have been added to the others and hence would have been negligible. It is probable that the light weight carried by each brick would not have been sufficient to prevent individual movement, and vertical expansion joints would not have been necessary.

The supported air cooled type of wall has been developed to prevent those failures peculiar to refractories which we have already discussed. It was also necessary to give consideration to other factors if the design was to be commercially satisfactory. Such a wall must be (1) of relatively low cost, (2) simply erected, (3) easily repaired, and (4) readily applicable to air cooling. This latter point is of great importance, as the cooling air must be recovered if high efficiencies are to be secured. This air varies in quantity and temperature, is sometimes primary air and sometimes secondary, and sometimes goes to a stoker wind box. Air passages must at times be large, at other times small, sometimes horizontal, sometimes vertical, and often combinations of both. The outer wall should sometimes be of brick or of insulating materials, and at other times of steel or transite board in order to save space.

By dividing the wall into relatively small, independent sections, the evils of expansion are eliminated. Vertical expansion may be confined to sections about 30 in. high, separated by asbestos packed expansion joints, which will also make for ease of erection and repair. In such a construction no tile is subjected to a pressure due to more than 30 in. of refractory, hence each tile can move independently, and sufficiently to care for individual tile expansion. The wall can be made air tight by external grouting, which will be on a relatively cool surface, subject to only negligible expansion. There is not sufficient weight on any one tile to produce deformation if high furnace temperature causes a tendency toward softening.

The fluxing action of the ash from coals which have ash of low fusion temperature must always be considered in designing any refractory wall. An ash that fuses below 2100 deg. fahr. will cause trouble with any refractory wall unless burned with about 40 per cent excess air. Air cooling alone will not suffice. When the size of unit or the load factor will not warrant the cost of all water cooled walls and when low excess air is necessary, partial water cooling, such as in a bridge wall or side walls, offers a very satisfactory compromise.

The refractory furnace has not outlived its usefulness. The development of the sectionally supported furnace wall, adapted for air cooling, has enabled it to forge ahead in a broad field. Wherever the radiation effect from hot brickwork is desirable, refractory walls and arches can be used with good economy. When sufficient furnace volume can be obtained, air cooled, sectionally supported, furnace walls are entirely practical. Such furnaces and walls have been operating with complete success over many years and in great number. Refractory construction may be supplemented by water cooled walls, where these are indicated by their particular characteristics, but refractories will apparently never lose their usefulness as a satisfactory material for furnace linings.

Modern Progress is Based on Engineering

STEAM plant engineers may well be proud of their achievements. They are contributing mightily to that vast economic and social structure that constitutes the Nation. More—they are helping to build this present age of civilization.

Progress has speeded up since the world war. In general, the chain store system is fast becoming recognized as the modern method of merchandizing. Monopoly is not the fearsome ogre that it was once, because its benefits are increasingly evident. Consolidation of capital and of human endeavor is a distinct trend of the times. In particular, communications by 'phone, by wire, by plane, by rail, and by radio have all but obliterated distance. The machinery used in our daily lives has suddenly reached substantial perfection. Our automobiles, our sewing machines, our phonographs, our vacuum cleaners, our radios, are such that children operate them. And those reservoirs of power, the steam-electric generating systems, are likewise enormously superior to those of the era before the war.

It is in this detail of the material structure that steam plant engineers have wrought. The power stations that dot the country are the very nerve centers of daily well-being. Proud may they be who have contributed to the economy and the day and night dependability of electricity, which through a nation wide network of thin electric wires, influences the lives, habits and accomplishments of each of us.

Flexibility *of* Pulverized Fuel Installation *of* Advantage *for* Large Units

By Otto deLorenzi
Combustion Engineering Corporation, New York

THE increase in size of steam generating units to such capacities as 800,000 lb. of steam per hour has emphasized the flexibility of pulverized fuel firing. For the moment at least, firing with pulverized coal has outdistanced stokers in the matter of capacity for a single unit.

Flexibility is perhaps the outstanding feature of the pulverized coal method. There would seem to be no limit in size of steam generating unit imposed by the feeding and burning of very large quantities of pulverized coal in a single furnace. The limitations are rather those of structure than of firing method, and it is by no means apparent that a limit in this direction has yet been reached.

"An engineering jest!" Such was the scornful characterization of pulverized fuel only a few years ago. Today, the design of a contemplated unit for a million pounds of steam per hour from a single steam generating unit, will scarcely consider any other combustion method for the enormous fuel rates required. This article discusses briefly the equipment used today, not in an engineering jest, but in what has come to be an engineering standard in combustion method.

Pulverized fuel has long since ceased to present any very difficult problems. Pulverizing itself has been thoroughly mastered. Conveying the pulverized fuel is satisfactorily accomplished. Burners for both primary air alone, and for total air, are commercially standardized.

The growth of the art has seen the development of two rather distinct systems of pulverized fuel preparation. In the storage system, raw coal is delivered to pulverizing mills and the pulverized coal is in turn delivered to storage bins, from which it is transported to the burners at a rate depending on the boiler load. There is a separate fan for the air supply. The direct firing system, on the other hand, combines the pulverizer and fan in one unit which delivers both pulverized coal and air directly to the burner as required.

There are certain inherent characteristics of each system which appeal differently to different engineers. In general, a small existing plant when changed over to pulverized coal firing would be equipped with the direct firing system with its unit mills. Variable load on the pulverizer would be offset by the simplicity of the installation. Moderate range of operating capacities would be accepted as satisfactory.

A new plant of large steam generating units, whether industrial or central station, would be more likely to require the storage system. The mills, operating independently from the load on the plant, would be run at maximum efficiency whenever they were operated. There would be a larger number of burners in proportion to the size of furnace thus a wide range of fuel burning capacity would be secured at the highest possible efficiency for the entire range. Spare units of the pulverizing equipment and crossover connections in the fuel conveying system would contribute largely toward elimination of shut-downs due to the failure of any part of the combustion system. Both the space required for separate housing of the pulverizing equipment, and the complication of the more elaborate equipment, would be offset by the insurance of continuity of service, and by the maintenance of the highest possible efficiency at all loads.

During the development of pulverizing equipment, a good deal of trouble was experienced from the moisture in the coal. In fact, an increase in moisture content definitely lowered the capacity of a mill. Since it was impossible to avoid the natural moisture content of available coals, it was considered necessary to pass the coal through a dryer before going to the pulverizing mill. Separately fired horizontal rotary dryers of the kiln type were first tried. Then the vertical, gravity feed, waste heat type was developed, where hot flue gases were drawn through the comparatively thin vertical sheets of coal for removing the moisture. Later on, steam dryers were perfected. In these, the coal passes over a series of steam heated grids and a current of air carries away the moisture from the hot coal. Dryers, at best, are cumbersome and add one more process to the handling of coal. Their cost was a material item of the total pulverized fuel system.

Dryers have to all intents and purposes been superseded by drying the fuel in the pulverizing mill itself. Hot air or flue gases are used to accomplish this drying.

As a general rule, pulverizers used for direct firing are of the high speed type. In these, the coal is pulverized largely by attrition. The rapidly revolving hammers stir the coal violently, and throw it against the housing, but it is probable that the larger percentage of pulverizing is the direct result of coal particles rubbing together and thus wearing down to the desired size. The feed of coal to the mill is regulated by a feeding device. In the mill shown in Fig. 1 there is a single pulverizing chamber. The hammers are pivoted between steel discs

which are attached to the main shaft, and the pulverizing is accomplished as previously described. The coal as it is pulverized is carried by an air stream

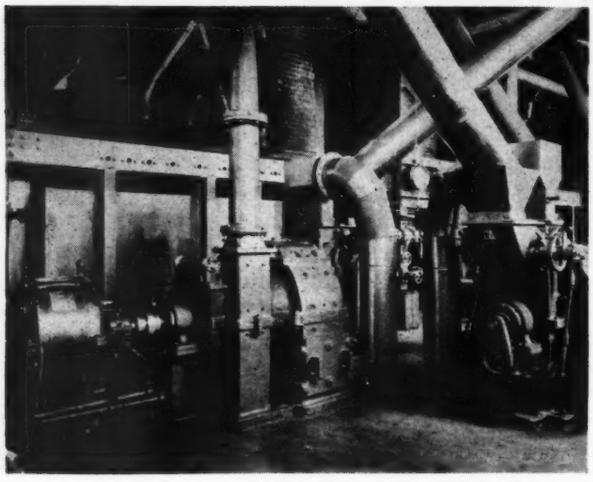


Fig. 1—Unit System Installation of Pulverized Fuel Firing. The two mills shown are of the impact type.

to the classifier mounted on the pulverizing chamber. In this classifier, the coarse particles are rejected and returned to the mill, while the fine coal is carried on to the mill exhauster which discharges it to the burner through suitable piping. Since with a direct fired system the feeding of fuel is directly dependent upon the pulverizing mill, it is necessary that this entire unit be of most substantial construction.

Pulverizers used in connection with the storage system are usually of large capacities. The mills, in practically all cases, are of the slow speed air swept type. In mills of this type pulverization is effected principally by direct crushing and only partially by attrition.

The mill illustrated in Fig. 2 is of the pendulum type. In this mill pendulums, carrying heavy rollers on their lower ends, are rotated by a central vertical shaft. Centrifugal force causes the roller to bear against the grinding ring or bull ring, as it is generally called. Coal is fed to the mill by a star feeder and is crushed between the bull ring and rollers.

Some of this coal drops to the mill base. Rotating plows are provided below the roller for picking up the coal in the base of the mill and throwing it in front of the rolls to be reground. The mill is air swept. Air enters the base of the mill through ports below the bull ring. The fine coal is picked up by the current of air passing through the mill and enters a cyclone separator. The air from the separator enters the exhauster which blows it to the mill. The excess air from the mill system is either vented to the atmosphere through suitable air washers, which remove the dust, or to the burner in the boiler furnace. In this system the mill exhauster is placed so that the cyclone separator is operated under suction. Thus the exhauster handles only air that contains a relatively small amount of dust, and therefore, the wear on the exhauster blades is considerably reduced.

Burners for handling pulverized fuel fall into two principal classes. In one class are those burners in which only part of the air for combustion is admitted along with the powdered fuel. It may be remarked that this type of burner is usually installed for firing the coal through the top of the furnace, or at a very steep angle through the front of the furnace near the top. The other class consists of burners in which all of the air for combustion of the pulverized fuel is admitted through the burner itself. This burner is therefore arranged to mix the air and the fuel in the furnace as close to the burner as possible. Various swirling devices are used for getting the powdered fuel and air into intimate contact. These burners are usually installed in the vertical front wall of the furnace at a distance from the bottom roughly one-quarter to one-third of the total height of the furnace.

The correct design of furnaces for burning pulverized fuel is a complicated procedure in that they must be proportioned with reference to the particular burner and firing method employed, with due consideration, at the same time, to both the contem-

Fig. 2—Installation of Pendulum, or Roller, Type Mills for storage system method of pulverized fuel firing.

plated load and the materials of which the furnace will be constructed. This is no job for the novice. The furnace should be designed as an essential link

in the combustion chain of transferring the heat of the fuel into the outgoing steam. Without doubt, experience is here the most important factor. Experience alone can economically combine the considerations for ideal combustion of the fuel with the considerations of construction costs.

Much has been written with regard to the volume of pulverized fuel furnaces. In a general way, the volume is a significant factor when combined with the heat liberation per cubic foot. A liberation of 40,000 B.t.u. per cubic foot has been attained and may, in some cases, be commercially advisable, but if the liberation is brought down to 20,000 B. t. u. or less per cubic foot, there is very likely to be both lower maintenance of the furnace, and a worth while increase in daily operating efficiencies. It is obvious that the 20,000 B. t. u. furnace will have twice the volume of the 40,000 B. t. u. Its cost will therefore be greater. The determination of size for any given installation should follow very closely the recommendation of the manufacturer of the pulverized fuel equipment. It is to his interest to recommend such sizes as will best combine all the variables of the problem so as to carry out most faithfully the desire of the purchaser for a truly economic installation.

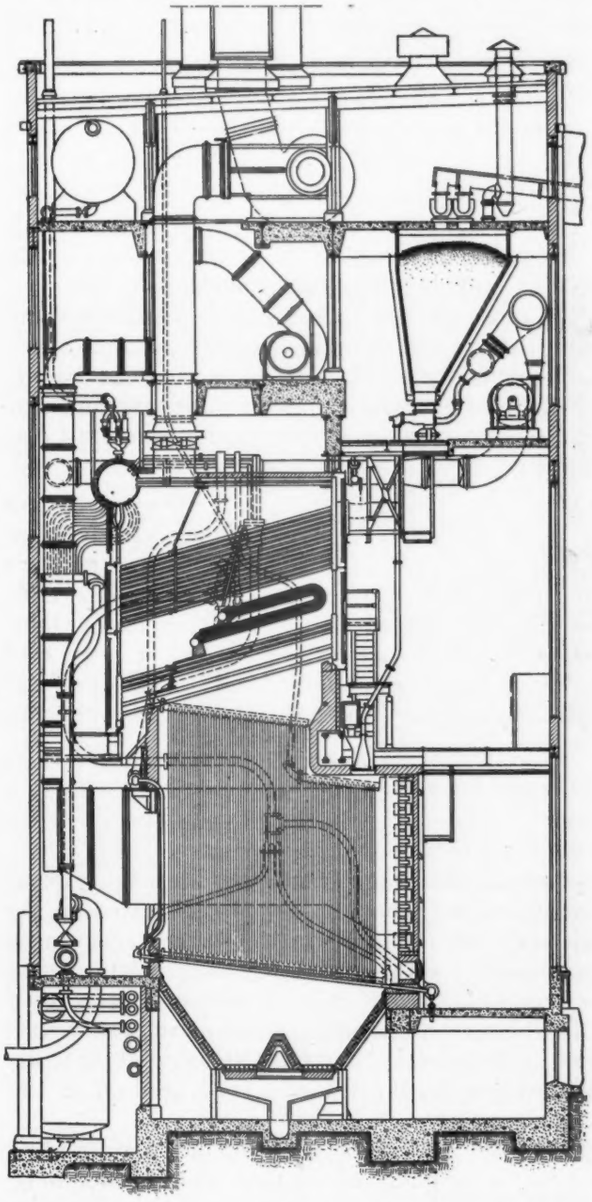


Fig. 3—Sectional view of installation using storage system and showing vertical firing.

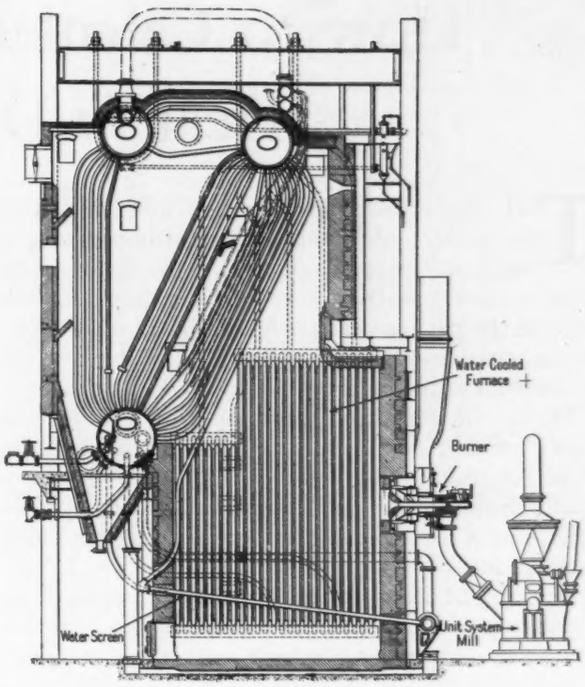


Fig. 4—Pulverized fuel furnace fired by horizontal type of burner.

Two Cent Stamp *vs.* Filing Cabinet

ECONOMY is not a theoretical affair, but an intensely practical one. It has to do with actual circumstances, not with imaginary ones. Moreover, it is seldom technical; rather it is applied common sense.

It takes will power to secure economy. That goes for curtailing one's daily pocket money, simplifying one's style of living, or effecting savings in one's business. The same variety of effort is required in each case.

He who will save a five cent car fare, but buy fifteen cent cigars, will very likely cuss the stenographer for spoiling a two cent stamped envelope and then order an unnecessary filing cabinet.

Eternal vigilance is the price of economy as well as of safety. The effort of will must be continually applied until it is a habit.

In a business organization economy must work from the top downward. If the boss is economical of his own time and energy, he will very likely teach the trick to his lieutenants. Thence it will percolate to the two cent stamp.

How to Calculate *the* Loss Due to Heat *in* Dry Flue Gas

THE heat represented by the various losses from the boiler and furnace is of great importance to the boiler plant engineer. Information as to these losses is usually of greater value than a knowledge of the per cent efficiency obtained, and a study of the variables affecting these losses will often lead to clues for reducing them.

While the formulas for computing the various losses are not complex, a more rapid method for their determination is often desirable. A series of charts has therefore been prepared for conveniently determining the principal losses that occur in a boiler and furnace.

The largest item of the heat losses of any heat generating and heat absorbing unit, such as a furnace and boiler, is usually the heat lost in the dry gases of combustion.

This heat loss is computed by multiplying the weight of dry gas per pound of fuel by the specific heat of the gas and by the temperature difference of the flue gases and air used for combustion, or, in symbols,

$$\text{loss (B.t.u.)} = W_g \times .242 \times (T_2 - T_1)$$

The weight of gas per pound of fuel is determined indirectly from the flue gas analysis.

The dry gas may be considered as consisting of carbon dioxide, oxygen, carbon monoxide and nitrogen, or, written in chemical symbols,

$$CO_2 + O_2 + CO + N_2$$

These gases are determined in the analysis in parts by volume. To convert them into parts by weight, they must be multiplied by their molecular or relative weights, thus,

$$44\ CO_2 + 32\ O_2 + 28\ CO + 28\ N_2$$

All carbon burned appears in the form of CO_2 and CO. As the atomic weight of carbon is 12 and as CO_2 and CO each contain 1 atom of carbon the weight of carbon equals $12\ CO_2 + 12\ CO$.

The dry gas per pound of carbon then is equal to,

$$\frac{44\ CO_2 + 32\ O_2 + 28\ CO + 28\ N_2}{12\ CO_2 + 12\ CO}$$

or simplifying,

$$\frac{11\ CO_2 + 8\ O_2 + 7\ CO + 7\ N_2}{3\ (CO_2 + CO)}$$

This may be written,

$$\frac{4\ CO_2 + O_2 + 7\ (CO_2 + O_2 + CO + N_2)}{3\ (CO_2 + CO)}$$

In this expression the CO_2, O_2, CO and N_2 are the parts by volume as determined in the analysis.

As $(CO_2 + O_2 + CO + N_2)$ represents all of the gases analyzed, and must equal 100 per cent, the equation may be written,

$$\text{Dry gas per pound of carbon} = \frac{4\ CO_2 + O_2 + 700}{3\ (CO_2 + CO)}$$

and if C_b = the carbon burned per pound of fuel fired, then,

$$\text{Dry gas per pound of fuel} = \frac{4\ CO_2 + O_2 + 700}{3\ (CO_2 + CO)} \times C_b$$

The complete equation for the loss in B.t.u. per pound of fuel may then be written,

$$\text{Loss in B.t.u.} = \frac{4\ CO_2 + O_2 + 700}{3\ (CO_2 + CO)} \times C_b \times .242 \times (T_2 - T_1)$$

This equation, while not strictly accurate since certain assumptions have been made, gives results close enough for all practical purposes.

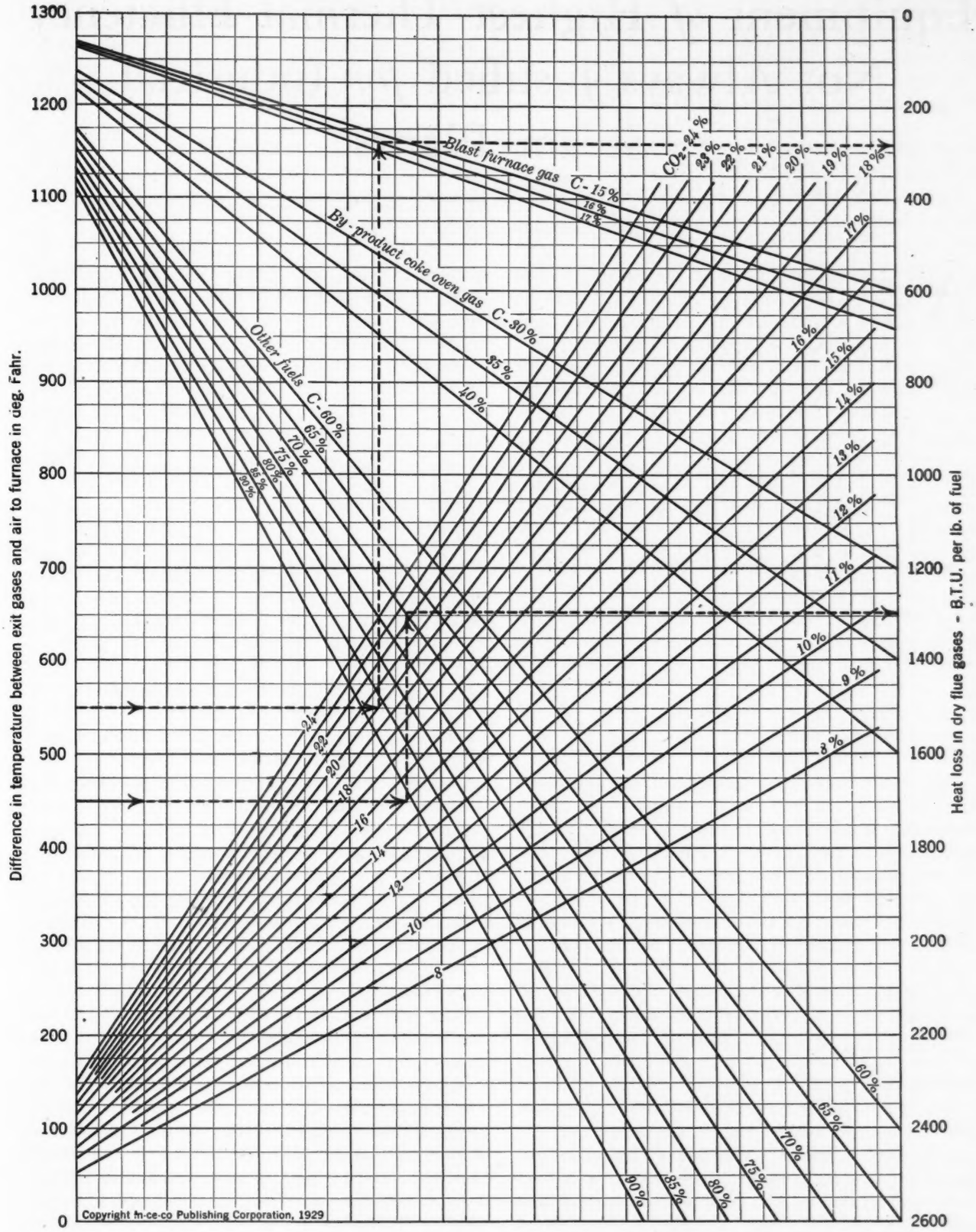
The chart on the opposite page presents graphically, the solution of this equation for all the conditions commonly encountered in practice. In order to demonstrate the practical use of this chart, an example has been selected involving the following conditions:

CO_2	15.0 per cent
O_2	4.0 per cent
CO	0.0 per cent
Air temperature	70.0 deg. fahr.
Flue gas temperature	520.0 deg. fahr.
Carbon in fuel (by analysis)	72.0 per cent
Carbon in refuse per pound of fuel	2.0 per cent
Carbon burned per pound of fuel	70.0 per cent

$$\text{The loss in B.t.u.} = \frac{4\ (15.0) + 4.0 + 700}{3\ (15.0) + 0} \times .70 \times .242 \times (520 - 70) = 1283$$

To obtain this result from the chart, the temperature difference (520 − 70) = 450 is located on the scale at the left. A line from this value is then traced horizontally to the intersection with the line of 15 per cent CO_2. From this intersection, trace vertically to intersection with the line of 70 per cent carbon (C), thence trace horizontally to the scale at the right, where the B.t.u. loss 1283, is read off on the vertical scale.

If the per cent carbon is of dry fuel then the loss in B.t.u. is per pound of dry fuel. If the loss is to be expressed in B.t.u. per pound fuel "as fired", then the per cent carbon should be of fuel "as fired".



No. 1—CHART FOR DETERMINING LOSS DUE TO HEAT IN DRY FLUE GAS

Equipment *of* Highest Thermal Efficiency Not Always Justified *for* Industrial Steam Plants

By H. G. Ebdon

Combustion Engineering Corporation, New York

ADVANCEMENTS made in the burning of fuel and the generation of steam have been so widely advertised that in a great many cases high thermal efficiency plants are being considered and installed without justification. On the other hand there are as many cases where full advantage is not taken of the more efficient equipment that has been developed. A few of the smaller industrial plants, in trying to approach central station operating results, lose sight of the fact that public utilities work on a much lower basis of return; that central stations have a comparatively high load factor and are tied in with other stations of the system thereby minimizing the amount of spare equipment necessary.

True economy is measured by the net return, and there are cases where high efficiency apparatus may actually increase operating charges for a given steam production. Mr. Ebdon, who has had many years of experience in balancing efficiency against economy, explains how to calculate true economy. The problem which he sets up is entirely worked out: the reader will be much interested in the result. This is the text of a paper delivered by Mr. Ebdon at the 25th convention of the Association of Iron & Steel Electrical Engineers.

The enthusiasm of the equipment manufacturers selling a particular piece of apparatus which forms only a part of the complete steam generating equipment, helps to keep the first condition alive, as they are not particularly interested in the net return of the complete unit; their interest being limited to installing a workable and satisfactory job only, as far as their individual equipment is concerned.

The stoker man tells you about high maintenance and slagging difficulties that can be expected with pulverized coal; also the troubles with wet coal. The pulverized fuel man claims that stoker equipment is out of date and you will be tied down to some definite grade of coal, for which a premium has to be paid. The air pre-heater enthusiast points out that economizers played an important part before the days of the extraction turbine but since then the air pre-heater is supreme in the recovery of heat from waste gas, and the economizer expert comes right back claiming high furnace and equipment maintenance with air pre-heaters and inaccessibility for cleaning. To complicate matters, each will substantiate statements with records from some particular plant.

We all know that there is a proper place for each of the different types of apparatus, but it is quite a problem to work out the most suitable application unless a competent consulting engineer is employed. Some of the larger manufacturing companies with a complete line of equipment are in a position to make an unbiased analysis of plant conditions as they are not limited to any particular type of fuel burning or heat absorbing equipment and purchasers are beginning to avail themselves of this service.

Previously, separate specifications were sent to all manufacturers in the field, and as 250 per cent of rating was considered good practice, the boilers were specified on this basis; although it may not have been an economical point of operation.

The boiler manufacturer would make exit gas temperature guarantees that were qualified by a gas analysis of 15 per cent CO_2. The stoker or pulverized fuel manufacturer would predicate his efficiencies on certain boiler exit gas temperatures, and the air preheater manufacturer would base his guarantees on a certain amount of combustion air being passed through the pre-heater. In checking up the operating costs and fixed charges, the engineer would find that the total expenditure was warranted and accordingly the equipment would be purchased.

After the apparatus was installed, acceptance tests were run and actual efficiencies were perhaps considerably below those guaranteed, but the boiler contractor was not liable because the stoker did not deliver 15 per cent CO_2. The stoker contractor would not be held because the boiler did not absorb the amount of heat on which his efficiency was based. Also, the setting leaked to some extent and a lesser amount of combustion air passed through the preheater. In each case the manufacturer predicated his guarantees on test limits—conditions that could not be obtained in practice, and on the basis of actual overall figures the equipment may not have been the profitable investment originally estimated. This illustrates one of the most important points in making an economical set up for a proposed power plant

—that is; correlating the performance guarantees of the individual manufacturers.

Another point of equal importance is the selection and proportioning of the number and size of units. Although 250 per cent continuous operation is con-

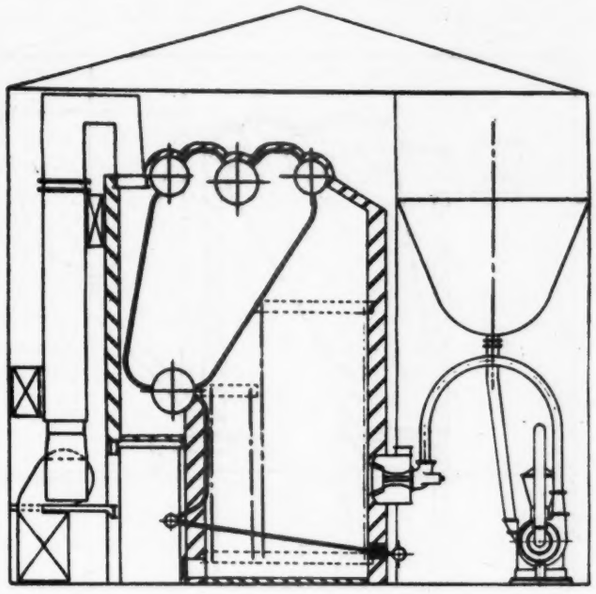


Fig. 1—CASE A showing combination of boiler, pulverized fuel firing, water cooled walls, and air preheater. Three boiler set up.

sidered commercially practical, it does not necessarily mean that an efficient and economical plant cannot be designed for lower ratings. In order to show the effect of coal cost and capacity factor, four different plant designs have been prepared showing the relation between initial investment costs and operating costs. The same general design is followed in Figs. 1, 2, 3 and 4, and a comparison is given between stoker firing and pulverized fuel firing, as well as between high and low ratings. All are based on a plant size of 100,000 lb. of steam per hour.

Case A covers a three boiler arrangement using pulverized coal at about 300 per cent of rating. Water cooled walls are used as well as air preheaters, and the furnace volume is kept down to within reasonable limits, allowing a heat release of 20,000 B.t.u. per cubic foot.

Case B covers four boilers at 188 per cent of rating with a furnace designed for 16,000 B.t.u. per cubic foot and both water cooled walls and air preheaters have been eliminated, although water screens are used to minimize ashpit slagging.

Case C is similar to case A, except that multiple retort stokers are used. Case D covers four stoker fired units with solid refractory walls and without air preheaters.

In all cases one boiler is kept as a spare and the assumed steam conditions are: 250 lb. pressure, 150 deg. fahr. superheat, and 210 deg. feed water.

Table 1 shows the operating performance and first cost of each plant, and Table 2 shows the yearly operating costs. These operating costs are given for four conditions: 3000 hours per year operation and $3. coal, 5000 hours operation and $3. coal, 3000 hours operation and $5. coal, and 5000 hours operation with $5. coal.

The figures given in Table 1 are comparatively accurate and show the relative costs of equipment being sold by one manufacturer. In working up this tabulation no attempt was made to prove anything except that there is a proper place for all classes of apparatus and no one combination is the solution of all conditions. The size of plant was picked at random, representing a fair average of industrial plants. In this particular instance, using a fixed coal cost, stokers show up more favorably than pulverized fuel. But in a large number of cases, slack coal, suitable for pulverized fuel operation, can be purchased at a lower price than properly sized stoker fuel, and if we assume a differential of $1 per ton in favor of coal for the pulverized fuel plant, we find that a pulverized fuel installation is much more economical than stokers. The plant with the highest thermal efficiency shows the highest operating cost with the low priced coal and low capacity factor, but it is apparent

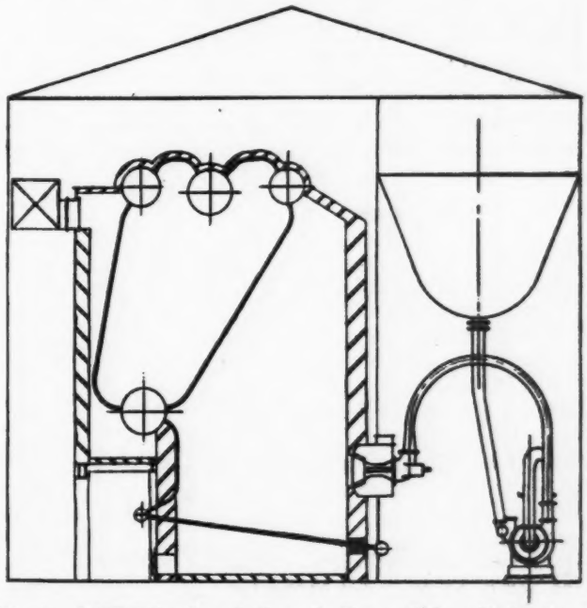


Fig. 2—CASE B for four boilers, similar to A, but eliminating air preheater and most of the water cooled walls.

that as either or both factors increase it is easier to justify the higher initial investment for more efficient equipment.

The maintenance and labor costs in Table 2 are merely relative and do not necessarily represent actual costs as they will vary with location of plant and labor conditions. The power cost is quite an item and is often overlooked.

In both cases A and C where air preheaters were used it was necessary to use an induced draft fan due

to the low final gas temperature and the increased resistance. The power required for the forced draft fan was increased approximately 25 per cent, and the total increased power cost, as well as the fixed charges on the induced draft fan and additional insulated ductwork, should be charged up to the air preheater application. In some plants, using turbine exhaust for process work, power is almost a by-product and does not have to be seriously considered.

Although this paper deals particularly with plant conditions in the average industrial field, it applies in general to all steam generating plants including those in the steel industry. Heretofore the steel mill power plant has had a haphazard growth as there was a surplus of blast furnace gas, but developments

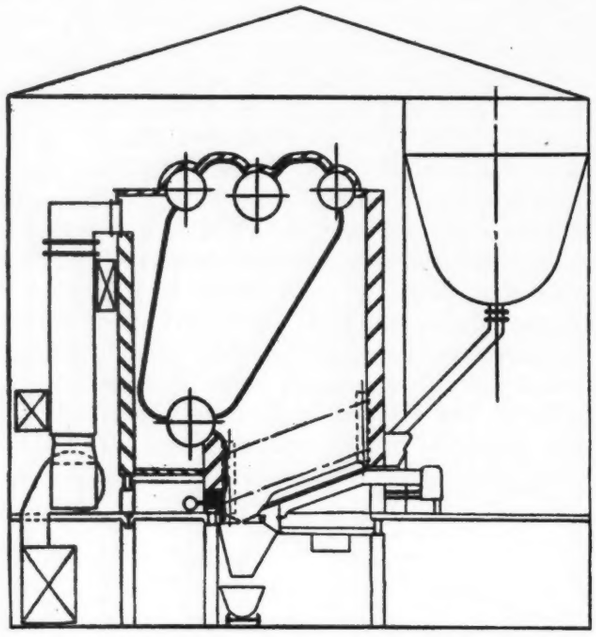


Fig. 3—CASE C—A three boiler set up, including air preheater and water cooled walls, but using stokers instead of pulverized coal firing.

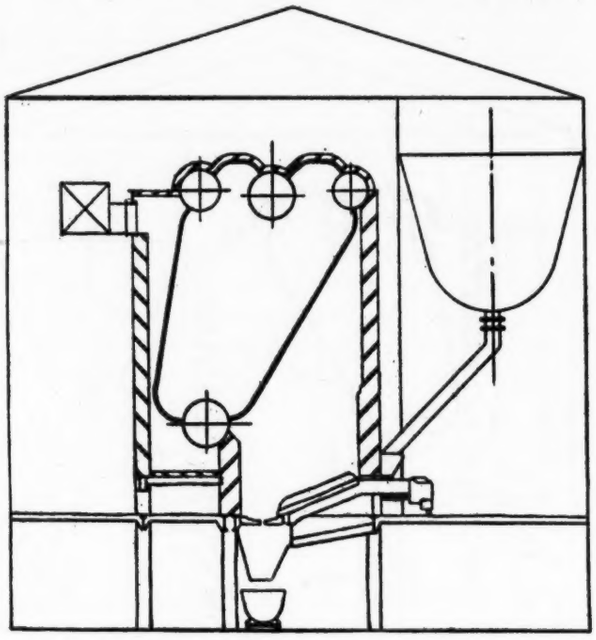


Fig. 4—CASE D for four boilers based on stoker application, omitting water cooled walls and air preheater.

TABLE I

Case	A	B	C	D
Method of Firing	Pulverized Fuel		Stokers	
No. of Boilers Selected	3	4	3	4
Building Volume . . . cu. ft.	183,000	190,000	171,000	192,000
No. of Boilers on Line	2	3	2	3
No. of Boilers Spare	1	1	1	1
Per Cent Rating (Boiler only) . . . per cent	296	188	282	188
Boiler Heating Surface . . . sq. ft.	5,600	5,880	5,880	5,880
Water Wall Heating Surface . . . sq. ft.	600	....	....	....
Air Pre-heater Surface . . . sq. ft.	7,000	....	5,000	....
Combustion Rate . . . B. t. u., per cu. ft.	20,000	16,000	....	....
Combustion Rate . . . Lb., per sq. ft.	....	....	43	36
Gas Temp. Leaving Boiler . . . deg. fahr.	630	545	630	550
Gas Temp. Leaving Air Preheater . . . deg. fahr.	370	....	430	....
Test Efficiency . . . per cent	84	79.5	82	78.5
Operating Efficiency . . . per cent	82	77.5	78	74.5
COST				
Building	$55,000	$57,000	$51,300	$57,600
Boilers	30,000	41,000	31,000	41,000
Superheaters	8,500	11,600	8,700	11,600
Soot Blowers	2,700	3,700	2,700	3,700
Air Preheaters	15,000	....	11,000	....
Fan Equipment	13,000	8,000	13,000	8,000
Ducts	12,500	6,000	12,500	6,000
Water Cooled Walls	27,800	10,000	14,400	....
Setting, Steel Work and Hoppers	36,800	46,400	24,000	32,000
Coal Burning Equipment	34,200	39,500	26,700	29,600
Breeching and Stacks	4,000	10,000	4,000	10,000
TOTAL COST	$239,500	$233,200	$199,300	$199,500

in electrification have put the power requirements beyond that obtainable with the blast furnace gas supply and more efficient equipment is required to get the most out of the fuel. As the demand for power has increased it meant adding coal burning units to carry the load, and the newer installations are designed for using both blast furnace gas and coal in the same furnaces.

The Youngstown Sheet & Tube Company recently installed five 2000 hp. boilers, each capable of meeting the steam demand with either blast furance gas or pulverized fuel. The Gulf States Steel Company at Alabama City has a new steam plant with four 900 hp. boilers of similar design.

The Bethlehem Steel Company at Sparrow's Point has two 1300 hp. units as well as two steam generators equipped for both types of firing, and the steam generators have complete water cooling on all four sides without any refractory exposed to the furnace. Each of these units delivers approximately 100,000 lb. of steam with blast furnace gas, and the furnace volume is only 5000 cubic feet. Both air preheaters and economizers are installed. The results at this plant have exploded the theory that for pulverized fuel firing of fuel, reflected heat from refractories is necessary to maintain ignition and high CO_2.

The Inland Steel Company is about to extend its plant with 1790 hp. boilers and economizers. Water cooled walls will be installed and pulverized coal will be used to take the fluctuations.

These installations indicate the trend of improvements necessary in the steel mill power plant to cut production costs, and while the generation of power is considered as only an auxiliary operation, it represents quite a percentage of the total cost. The capacity factor of a steel mill power plant running 24 hours a day affords a real opportunity to justify highly efficient equipment. Of course, it is necessary to go through the same stages of economical proportioning and selection as set forth in the first part of this arti-

TABLE II
Operating Costs

	Case A	Case B	Case C	Case D
$3 coal—3000 hours operation per year				
Fuel Cost	$45,300	$47,700	$47,400	$49,600
Labor	20,000	20,000	24,000	24,000
Maintenance	1,530	2,860	2,240	3,640
Power	7,500	4,300	5,600	2,240
Desired Return on Investment, Including Fixed Charges, Total, 25 per cent.	59,875	58,300	49,842	49,875
TOTAL COST	$134,205	$133,230	$129,082	$129,355
$3 coal—5000 hours operation per year				
Fuel Cost	$75,500	$79,500	$79,000	$82,700
Labor	24,000	24,000	30,000	30,000
Maintenance	2,550	4,770	3,730	6,060
Power	12,500	7,300	9,600	3,730
Desired Return on Investment, Including Fixed Charges, Total, 25 per cent.	59,875	58,300	49,842	49,875
TOTAL COST	$174,425	$173,870	$172,172	$172,365
$5 coal—3000 hours operation per year				
Fuel Cost	$75,500	$79,500	$79,000	$82,700
Labor	20,000	20,000	24,000	24,000
Maintenance	1,530	2,860	2,240	3,640
Power	7,500	4,370	5,600	2,240
Desired Return on Investment, Including Fixed Charges, Total, 25 per cent.	59,875	58,300	49,842	49,875
TOTAL COST	$164,405	$165,030	$160,682	$162,455
$5 coal—5000 hours operation per year				
Fuel Cost	$126,000	$132,500	$131,600	$137,700
Labor	24,000	24,000	30,000	30,000
Maintenance	2,550	4,770	3,730	6,060
Power	12,500	7,300	9,600	3,730
Desired Return on Investment, Including Fixed Charges, Total, 25 per cent.	59,875	58,300	49.842	49,875
TOTAL COST	$224,925	$226,870	$224,772	$227,365

cle. Several methods have been advanced for the determination of economic value, but in most cases they have proved impractical. Manufacturers can become overly optimistic with regard to capacities and efficiencies, especially as few plants are equipped to check accurately the guaranteed performance, and such a condition cannot be corrected in fixed formulas of valuation. This makes it necessary to allow a credit for some things that do not show up in the price, and these are the reputation, ability and experience of the manufacturer in his own industry and the value of his service organization.

The least number of separate contracts that can be let on a particular job is also of importance. There is a sufficient number of manufacturers in the power plant field capable of handling complete fuel burning and steam generating installations to secure competitive bids; and with one contract the coordination of equipment is simplified; the approval of drawings facilitated; the proper timing of shipments is assured; erection work and the starting of the apparatus are expedited, and one set of guarantees confine to one manufacturer the responsibility for the performance of each individual element and the overall performance of the complete unit.

Giant Power Plant for Industrial Chicago

Formation of the Industrial Power Corporation for the processing of coal and the furnishing of electrical power, gas and steam to the manufacturing district of Chicago, including Packingtown, the Central Manufacturing District, the Union Stock Yards and Transit Company and adjacent territory, by a group of Boston, New York and Chicago business and industrial interests, has just been announced.

The Industrial Power Corporation, a Delaware corporation, has been privately financed and has outstanding $10,000,000 of 6 per cent preferred stock and 200,000 shares of common stock, no par value. Subsidiary companies will be formed later and will operate in Indiana, Minnesota, Missouri, Michigan, Iowa and Wisconsin, where the Industrial Power Corporation has secured exclusive state rights to the processes for the low temperature carbonization of coal.

The new project when completed will cost approximately $40,000,000 and will unquestionably be the largest development of its kind in this country and the first comprehensive combination of the low temperature distillation of coal processing, with the generation of electrical current, the production of gas and the manufacture of domestic fuel. Stevens & Wood, utility engineers, are completing a survey, begun a year ago, of the properties to be served by the new development, and are preparing plans for the new central station and the low temperature carbonization plant with the necessary provisions for combining the properties into a self-contained system. Work on the new plants will be started immediately and the present schedule calls for the delivery of service to the Chicago industrial area the early part of next year.

The Industrial Power Corporation has taken over the properties of the Produce Exchange Corporation, an Illinois utility company which has been operating successfully for many years, but which, because of plant inadequacy, has been able to supply power to only a small part of the manufacturing plants located in the Central Manufacturing and Stock Yard Districts which consume 5,000 tons of coal a day.

The Industrial Power Corporation has also acquired extensive areas with frontage on the Chicago River, thus assuring an adequate water supply and dock facilities, the location being the geographical and industrial center of Chicago. Rights of way of streets have been secured, and right of way for gas mains and electrical transmission lines along the entire lines of the Chicago Junction Railway and Chicago River and Indiana Railroad Company are among the new corporation's assets. These easements provide immediate access to 25 of the 26 railroads entering Chicago, and with electrification of these lines imminent, Industrial Power Corporation can supply electricity for these developments.

Industrial Power Corporation will begin construction of a central station power plant, having approximately 100,000 kilowatt capacity and designed for an ultimate steam plant of twelve 2,500-horsepower high pressure boilers. The fuel for this central station will be secured from a coal processing plant in which all of the fuel used in the new development will be treated by low temperature carbonization to extract the most valuable constituents of the raw coal before the remaining solid fuel is released for power development and domestic use.

This low temperature carbonization plant will employ the same process for low temperature carbonization which has been in commercial use in Europe for the past five years and which was adapted to American practice by the plant now in operation at New Brunswick, New Jersey, the first unit of which is supplying 3,500,000 cubic feet of city gas daily to the Public Service Corporation of New Jersey.

The carbonizing plant at Chicago is designed for an ultimate capacity of 45,000,000 cubic feet of gas per day, all of which will find a ready market in the industrial area adjacent to the plant. The gas from this process is of especially high heating value and may be used directly for process work or blended with blue gas to meet the requirements of standard city gas.

NEWS

Stone & Webster Expanding

THE new $100,000,000 capitalization of Stone & Webster, Inc., is the first participation in this old established engineering and financial business that is available to the public. Forty years ago, the Stone & Webster business was started with but $4,000 capital, and ownership has hitherto been private. The new securities will be listed on the New York Stock Exchange. The business has expanded to such extent that some 60 public utility properties are owned or operated by this organization. With this change in capital structure, there is no change in the management.

A further step in the Stone & Webster, Inc., expansion, is the capital increase of Stone & Webster Associates Corporation, to 100,000 shares of no par value. This corporation was organized to undertake the promotion and development work connected with the operation or supervision of public utility properties in the United States, Canada and West Indies controlled or under management contract with Stone & Webster.

THE NATIONAL CONVENTION of the National Association of the Power Engineers is to be held at Chattanooga, Tenn., September 9-13. At the same time there will be a splendid exhibition in the Memorial auditorium, in which some 125 of the largest manufacturers of power equipment in the country have already engaged space.

It is expected that the convention will bring 5,000 visitors to Chattanooga.

F. A. MERRICK has been elected president of Westinghouse Electric and Manufacturing Company, succeeding E. M. Herr who resigned on account of ill health. Mr. Merrick has been vice president and general manager of this company since 1925, and served in responsible positions, both in the United States and Canada, for over twenty-five years.

CONSOLIDATED ASHCROFT HANCOCK CO., INC., announce the change in address of their general sales offices from New York to Bridgeport, Conn.

G. A. BINZ has been appointed Assistant to the Vice President in direct charge of Industrial Sales Research. W. P. BRADBURY has been appointed General Sales Manager. N. B. CARLTON has been appointed Western Sales Manager, located at Chicago.

THE PERMUTIT COMPANY, manufacturers of water softeners, filters, and other apparatus for removing impurities from water, has announced the opening of a new branch office located in the Montgomery Building, Spartanburg, S. C. This office will be in charge of Mr. R. V. Irwin, who for the last six years has been manager of The Permutit Company's office in Chattanooga, Tenn. Mr. Irwin's new territory will comprise North Carolina, South Carolina, and the eastern portion of Georgia.

ANNOUNCEMENT IS MADE by The Brown Instrument Company, Philadelphia, Pa., that C. H. Kerr has been appointed Vice President and General Manager, and G. W. Keller, Vice President and General Sales Manager.

IN ORDER TO TAKE CARE of their increasing business, the Plibrico Jointless Firebrick Company, of Chicago, have purchased 1200 acres of the finest flint and clay deposits, at the town of Firebrick (near Portsmouth, Ohio). The plant now manufacturing fire brick on this property will be remodelled for manufacturing the furnace lining material which has long been the product of the Plibrico company. This new plant at Firebrick is the third plant put into operation for producing the Plibrico furnace linings; the other two plants are at Chicago and Trenton.

THE PREST-O-LITE COMPANY, INC., has recently added two new acetylene gas plants located at 540 E. 17th Street, Wichita, Kansas, and at Jones Street and Pennsylvania R. R., Youngstown, Ohio. These plants will supply local industry with dissolved acetylene for oxy-acetylene welding and cutting.

Mr. H. Wilson is superintendent of the Wichita plant, which commenced operations on June 28th, and Mr. W. Webert, whose headquarters are at the North Kansas City plant, is district superintendent.

Mr. A. C. Mattison is superintendent of the Youngstown plant, which commenced operations on July 3rd, and Mr. C. G. Holt, whose headquarters are at the Pittsburgh plant, is district superintendent.

THE STEPHENS-ADAMSON MANUFACTURING COMPANY, Aurora, Ill., manufacturer of conveying equipment, announces the appointment of H. W. Newton as district manager of the Birmingham, Ala., office located at 1108 Martin Building, Birmingham. Mr. Newton was formerly designing engineer for his company.

KENNETH SEAVER, formerly general sales manager of Harbison-Walker Refractories Company, Pittsburgh, Pa., has been elected a vice-president of his company.

JOHNS-MANVILLE CORPORATION, New York, has announced the removal of the Milwaukee District Sales Office to the Railway Exchange Building, 97 East Wisconsin Ave., Milwaukee, Wis.

ELLIOTT COMPANY, Jeanette, Pa., announces the appointment of J. R. McDermet as Chief Engineer. Mr. McDermet has been a member of the Elliott organization for twelve years and for the past five years he has been in charge of the heater and deaerator divisions.

S. C. Miller has been appointed district manager of the Elliott Company with offices at 1101 Security Building, Denver, Colo.

THE DAMPNEY COMPANY OF AMERICA, Hyde Park, Boston, Mass., has opened a direct company branch office to serve the New York Metropolitan territory. The new address is Room 502, Engineering Building, 114 Liberty Street, New York.

COMBUSTION ENGINEERING CORPORATION, in order to assure the most efficient service to the rapidly growing Industrial South, announces the division of its former Atlanta district into three sections, with the following personnel, all effective July 1, 1929.

T. W. Battle has been appointed District Manager of the Charlotte Territory, with offices at 919 Johnston Building, Charlotte, N. C.

E. L. Shuff has been appointed District Manager of the Atlanta Territory, to succeed T. J. Cleary, resigned, with offices at Candler Building, Atlanta.

E. C. Walthall has been appointed District Manager of the New Orleans Territory, with offices at 1118 Union Indemnity Building, New Orleans, La.

EDWARD C. BROWN, formerly located at Buenos Aires as Foreign Manager of the Dearborn Chemical Company has been elected Vice-President and will serve as Eastern Manager with offices at 205 East 42nd Street, New York. Mr. Brown succeeds Grant W. Spear, who has resigned after twenty years' service as Vice-President and Eastern Manager.

W. M. Campbell will succeed Mr. Brown at Buenos Aires.

W. P. THOMAS, formerly Secretary of the Diamond Power Specialty Corporation, Detroit, Mich., has been elected Vice President.

This company also announces the opening of a branch office at 12 East 41st Street, New York City, for taking care of its business in the metropolitan area. Representation by Vincent Gilson is superseded by an entirely new company personnel. L. W. Nones is in charge of the office, with title of Eastern Sales Manager, and is assisted by R. L. Townsend, H. D. Folinsbee, Jr., and W. J. Fitzburgs.

THE GRISCOM-RUSSELL COMPANY, New York City, manufacturer of evaporators and heat exchange apparatus, announces the opening of a new district sales office in the Lewis Building, Portland, Oregon. Harry A. Brod has been appointed district manager in charge of the Portland district.

ARTHUR D. LITTLE, president, Arthur D. Little, Inc., Consulting Engineers of Cambridge, Mass., delivered an address "Science and Labor" July 9, before the Society of Chemical Industry, at Manchester, England. He has been awarded the honorary degree of Doctor of Science by the University of Manchester and Honorary Associateship in the Manchester College of Technology.

THE IRONTON FIREBRICK COMPANY, Ironton, Ohio, has elected the following officers: E. F. Myers, president and treasurer; W. P. Lewis, vice president; C.E. Bales, vice president and W. D. Lewis, secretary.

O. C. MERRILL resigned July 1st as executive secretary of the Federal Power Commission to assume charge of the American section of the World Power Conference.

WILLIAM L. ABBOTT, chief operating engineer of the Commonwealth Edison Company has received an honorary degree of LL.D. from the University of Illinois in recognition of his outstanding work in engineering.

Thomas E. Murray Dies

THOMAS E. MURRAY died of heart disease, on July 21, at his home, Wickapogue, L. I. He was sixty-eight years old, and was noted for his wide activities in the electric power plant field.

Forty-five years ago Mr. Murray, who was then employed in the water works at Albany, was placed in charge of the plant. He later took charge of the Albany Municipal Gas Company, and was shortly thereafter selected by Anthony N. Brady as one of his chief assistants in the acquisition of control of large public utility enterprises.

Mr. Murray organized the Edison Electrical Illumination Company of Brooklyn, which later became the Brooklyn Edison Company. He was one of the original directors and organizers of the New York Edison Company and the United Electric Light and Electric Power Company. In addition to this activity, Mr. Murray owned privately the Metropolitan Engineering Company, the Metropolitan Device Corporation, the Murray Radiator Company, and Thomas E. Murray, Inc.

NEW CATALOGS AND BULLETINS

Any of the following literature will be sent to you upon request. Address your request direct to the manufacturer and mention COMBUSTION Magazine

Air and Vacuum Equipment

"Triple-A" Blowers, Centrifugal Air Compressors, Exhausters and Vacuum Cleaning Equipment for industrial use are shown and described in a new bulletin A-50. Details of construction, performance characteristics and application arrangements are well covered. 12 pages 8½ x 11—Allen Air Appliance Co., 452 Lexington Ave., New York.

Appraisal Reports

Two new bulletins on the subject of Appraisals, are available. Bulletin No. 501 "Appraisal Reports" is a 12-page booklet describing the various uses of appraisals, the methods by which they are each prepared, and the benefits to be obtained from them. Bulletin No. 505 "Retrospective Appraisals" is a reprint of the regulations issued by the Internal Revenue Department covering the preparation and use of appraisals in Federal Tax cases—Lockwood Greene Engineers, Inc., 100 East 42nd Street, New York City.

Automatic Control Valves

"Bristol Automatic Electric Control Valves" is the subject of a new catalog No. 2000 which is profusely illustrated to show the details and application of apparatus for temperature control. Several pages are given to the description of temperature control instruments of both the indicating and recording types. 20 pages, 8½ x 11—The Bristol Company, Waterbury, Conn.

Barometer and Vacuum Recorder

A new bulletin No. 150 describes the Uehling Combined Barometer and Vacuum Recorder, an instrument for recording condenser performance in steam turbine operation. It is described as a dependable instrument which gives the turbine operator "something to shoot at," in that it shows at a glance the absolute back pressure and enables him to maintain the highest vacuum possible for a given barometer reading. The recorder chart indicates the exact time when anything happens to cause a drop in the vacuum and enables the operator to correct conditions that caused the interruption in service. 6 pages, 8½ x 11—The Uehling Instrument Company, 473 Getty Avenue, Paterson, New Jersey.

Boiler Control

The Balanced Draft System of Boiler Control is presented in a new bulletin No. 129. A line drawing of a typical installation shows the method of installing the control system and supplementary illustrations cover the details of the apparatus. 4 pages, 8½ x 11—The Engineer Company, 17 Battery Place, New York City.

Coal and Ash Handling

The Hahn line of coal and ash handling equipment is briefly described in a folder which reprints condensed catalog information. Steam Jet Ash Conveyors, Cast Iron Sectional Tanks and Bins, and Track Hoppers are presented. 4 pages 8½ x 11—Hahn Engineering Co., Division of Lancaster Iron Works, Lancaster, Pa.

Control Switch

Bulletin No. 848 describes the Industrial Type Mercoid Control Switch which is actuated by changes in either pressure or temperature. The switch is used to start and stop electric drive motors and operates between pressure or temperature limits for which it is set. A variety of types are available for a wide range of requirements. 16 pages, 8½ x 11—American Radiator Co., Accessories Division, 40 West 40th St., New York City.

Dry Quenching of Coke

The new Sultzer Dry Quenching installation at Consumers Power Company, Flint, Michigan, is briefly described in a new folder which includes a full page cross section drawing of the coke cooling plant. 4 pages, 8½ x 11—Dry Quenching Equipment Corporation, 200 Madison Avenue, New York City.

Feed Water Heaters

Catalog No. 90 describes the Hoppes Exhaust Steam Feed Water Heaters and Deareator Heaters. Supplementary chapters are devoted to the presentation of other Hoppes steam plant equipment including V-Notch Meters, Feed Water Purifiers, Steam Separators, Oil Eliminators and Exhaust Heads. Numerous illustrations show the details and application of this equipment. 88 pages and cover, 6 x 9—The Hoppes Manufacturing Co., Springfield, Ohio.

Mechanical Stokers

A new condensed catalog of Mechanical Stokers has been issued by the Stoker Manufacturers Association. Forty-six types of stokers manufactured by the ten member companies of the Association are illustrated and described. 10 pages are devoted to general engineering information related to the application and operation of stoker equipment. 36 pages and cover, 8½ x 11—Address Wm. V. McAllister, Secretary, Stoker Manufacturers Association, Foot of Walker Street, Detroit, Michigan.

Powdered Fuel Equipment

"Powdered Fuel in Metallurgical Work" is a reprint of a paper presented by W. O. Renkin before the Fuel Division of the World Power Conference in London. The paper is an authoritative presentation of this important subject and includes many charts and illustrations which add to its value. 32 pages and cover, 6 x 9½—Combustion Engineering Corporation, 200 Madison Ave., New York City.

Refractory Cement

'Sairset, an air-setting, high-heat-resisting firebrick cement and Quik-Pach, a plastic refractory are presented in a well illustrated catalog which shows many uses and applications of these two furnace materials. 20 pages and cover, 8 x 10¾. A supplementary folder describes two super-refractories—Kruzite and Mizzon. 16 pages, 4 x 9—A. P. Green Fire Brick Company, Mexico, Mo.

Thermometers

A new catalog No. 65 illustrates and describes the Brown Indicating and Recording Thermometers for measuring temperatures from—40 deg. fahr. to +800 deg. fahr. Numerous charts reproduced in colors enhance the interest and value of this booklet. Many types of industrial applications are shown by well selected illustrations. 72 pages and cover, 8 x 10½—The Brown Instrument Company, Philadelphia, Pa.

Valves

The first two numbers of an interesting series of brochures have recently been issued showing the application of Jenkins Valves for use in Hospitals and Office Buildings. These folders are well illustrated and offer an artistic presentation of Jenkins Valves for specific applications. 6 pages, 8½ x 11—Jenkins Brothers, 80 White Street, New York City.

Water Level Indicator

A new folder describes the C-E Water Level Indicator, a simple water level indicating device which can be placed in any location where it is most desirable for convenient and easy reading. The natural separation in the column of hot water at the top and cold water below makes it possible to eliminate the difficulties and impractical use of packing. To prevent leakage in case the water glass should be broken, an automatic shut-off valve is placed in the circuit directly above the glass This device is especially desirable from a convenience standpoint. By having cold water only, in contact with the glass, the usual round glass is suitable for high pressures. 4-page folder—WL-1, 8½ x 11—Combustion Engineering Corporation, 200 Madison Avenue, New York City.

Water Softening Equipment

Two new bulletins describe the Graver Water Softening Equipment. Bulletin No. 5049 illustrates and describes the Graver Hot Process Softener. 14 pages, 8½ x 11. Bulletin No. 5079 presents the Graver Cold Process Softener. Each method is comprehensively explained and numerous illustrations show the details of the two processes. 10 pages, 8½ x 11—Graver Corporation, East Chicago, Indiana.

NOTICE

Manufacturers are requested to send copies of their new catalogs and bulletins for review on this page. Address copies of your new literature to

COMBUSTION

200 MADISON AVE., NEW YORK

REVIEW OF NEW TECHNICAL BOOKS

Any of the books reviewed on this page may be secured through In-Ce-Co Publishing Corporation, 200 Madison Avenue, New York

Arc Welding

This book is peculiar in that there are seven authors and a separate editor, all expert in the line of arc welding

UNDER auspices of The American Society of Mechanical Engineers, the Lincoln Electric Company, of Cleveland, Ohio, offered several cash prizes, amounting to $17,500, for the best papers to be submitted on the subject of arc welding. Twenty-seven papers were submitted. The three prize winners and four other papers of special merit were selected for publishing in an informative book. *Arc Welding*, thus expressing the views of a number of experienced men, is of special value both to those actively engaged with this modern process and to those who seek the best and latest information on this subject.

The theoretical aspect of arc welding is sufficiently explained, and its practical application to many different fields is thoroughly covered. Informative illustrations in all of the papers render the subject matter exceedingly clear. Exact details of procedure are carefully specified, and many tables of dimensions cover a wide range of welding problems. Results from practical usage of arc welds are discussed.

Arc welds have been the subject of very many exact tests for strength, for repeated strains, and for durability. The various authors have cited many such authoritative tests, and numerous tabulations set forth clearly the demonstrated results.

Perhaps the most important division of this subject of arc welding is the economic phase. Where and when does arc welding prove equal to or cheaper than other methods of uniting metals? Where arc welding is cheaper, just why is it cheaper? What are the factors in detail that result in cheapness? Is the labor item on the side of saving, and can the material to be handled be reduced in weight if arc welded? Is there saving in the shop, or in the field, or in both places? Three of the articles deal with this important matter, so that the reader may check between three independent sources of data in one volume.

The authors of the seven papers are James W. Owens, of the Newport News Shipbuilding and Dry Dock Company, Newport News, Va.; H. Dustin, Professor in the University of Bruxelles; H. E. Possell, of the U. S. Naval Academy; Frank B. Walker, of the Eastern Street Railway Company in Boston, Mass.; B. K. Smith, of Big Three Welding and Equipment Company, Houston, Texas; M. M. Kennedy and F. H. Weiland, of U. S. Navy Yard, Philadelphia, Pa.; W. H. Himes, Wilkinsburg, Pa.

The book *Arc Welding* has 421 pages, of clear, readable type, interspersed with photographs, drawings, tables and diagrams. It is a 1929 book and therefore right up to the minute in advanced information. The price is $5.00. The book is in the standard 6 x 9 size and is substantially bound in cloth covers.

Materials Handbook

By GEORGE S. BRADY

IT is entirely safe to predict that this little book is going to be consulted frequently by every person who has access to a copy. It is an encyclopedia, in 4 in. x 7 in. size and 428 pages, of the materials used generally in the manufacturing arts.

Each material is most compactly defined and described. Its fields of usefulness are mentioned. Its composition is accurately stated and its customary method of shipping is given.

No purchasing agent need ask what is meant by Hybnickel, Silcrome, Diatomaceous earth, Benzol, Radium, Tripoli, or practically any other material that enters into manufacturing or the scientific trades. An engineer can read concisely the outstanding facts about Silicon, Manganese Steel, Gunite, Elektron, Bakelite, Aluminum alloys, and all of the marketed steels and commercial alloys. The chemist will find specifications for chemical materials. All of the woods and manufacturing materials of vegetable origin are described. The book is actually a complete encyclopedia of materials.

Indexing is simplicity itself. The materials, in the body of the book, are arranged in alphabetical order. The index, preceding the reading matter, is by groups such as Building Materials, Heat-resisting Alloys, Irons, Refractories, Woods. A few handy tables are grouped in a short appendix.

The ever pressing question, "What is Monel Metal," for example, is answered exactly as one would desire. Its origin, composition, properties, melting point, characteristics and its uses are explicitly and concisely stated in about one-third of a page. No loss of time, no unnecessary words. In a couple of minutes the question is definitely answered.

The individual needs but one copy of this useful book: a business house needs a number of copies for its various departments. The price is $4.00.

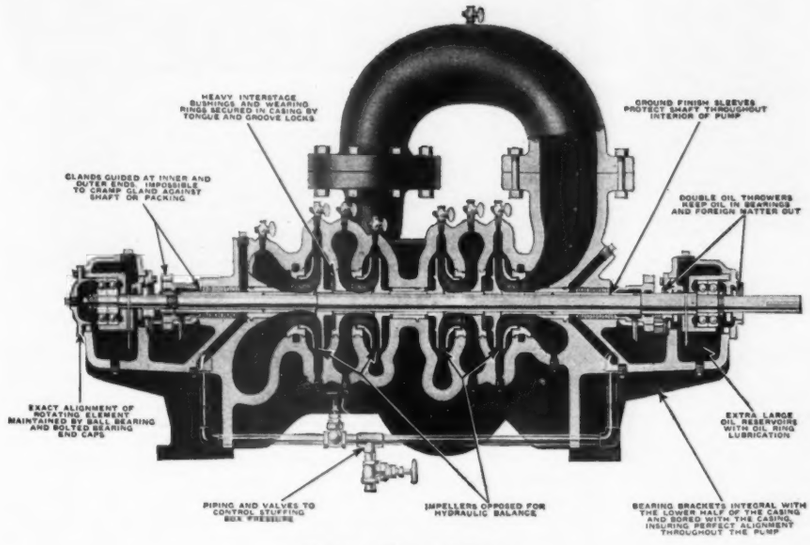
• NEW EQUIPMENT •

A New Centrifugal Pump for High Pressure Boiler Feeding

A NEW multi-stage centrifugal pump, for maximum total pressure of 900 lb. per sq.in. has been developed by Goulds Pumps, Inc., of Seneca Falls, New York. This pump is made in 2-stage and 4-stage types, and has many important features to recommend it for high pressure boiler feed service.

Bronze fitted construction is standard for boiler feeding. Impellers, wearing rings, interstage bushings, shaft sleeves, throat bushings, and liquid throwing collars, are all bronze. Alloy cast iron is used for the casing, and the shaft is alloy steel, heat treated.

The complete unit consists of pump, bed plate, and suitable flexible coupling. Special parts in special metals or specially treated may also be under specification.


HEAVY INTERSTAGE BUSHINGS AND WEARING RINGS SECURED IN CASING BY TONGUE AND GROOVE LOCKS
GROUND FINISH SLEEVES PROTECT SHAFT THROUGHOUT INTERIOR OF PUMP
GLANDS GUIDED AT INNER AND OUTER ENDS. IMPOSSIBLE TO CRAMP GLAND AGAINST SHAFT OR PACKING
DOUBLE OIL THROWERS KEEP OIL IN BEARINGS AND FOREIGN MATTER OUT
EXACT ALIGNMENT OF ROTATING ELEMENT MAINTAINED BY BALL BEARING AND BOLTED BEARING END CAPS
EXTRA LARGE OIL RESERVOIRS WITH OIL RING LUBRICATION
PIPING AND VALVES TO CONTROL STUFFING BOX PRESSURE
IMPELLERS OPPOSED FOR HYDRAULIC BALANCE
BEARING BRACKETS INTEGRAL WITH THE LOWER HALF OF THE CASING AND BORED WITH THE CASING, INSURING PERFECT ALIGNMENT THROUGHOUT THE PUMP

Section Through Pump

The speed of 3540 r.p.m. results in four particular advantages. Smaller impellers are used (than for 1750 r.p.m) for the same pressures, and the area on which any unbalanced end thrust loads would play is reduced to one-quarter, so that the total end thrust to be taken care of by mechanical means is reduced to a minimum. Better efficiencies are obtainable with higher speed. A smaller diameter shaft is permissible, and the surface area of shaft to be packed is less. A lighter and more compact pump is obtained.

Two sets of opposed impellers eliminate practically all end thrust. Any thrust that does develop is absorbed by the double row ball bearings at outboard end of shaft. Special balancing devices are eliminated.

The double guided stuffing box glands are new in centrifugal pump practice. Cramping of the packing or pinching on shaft is impossible. The rubbing speed between shaft and packing is no higher than with 1750 r.p.m. Only one-half of the pressure generated by the pump is on the discharge stuffing box. Piping is connected to the seals for connection to the pump suction, and valves are used to control the pressure on each stuffing box. Gauge connections are also provided.

The shaft is not only protected by renewable sleeves, but renewable bushings are also provided in the casing, giving complete protection to both. Each pump is subjected to a static test of 1800 lb., and also a performance test, and a test for end thrust.

Yarway Type C Seatless Blow-off Valves for High Pressures, Having Special Long Stroke

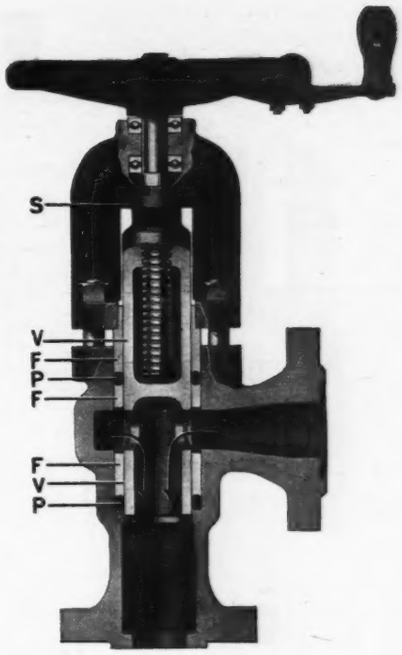
In order to meet high pressure steam power plant conditions which have rapidly become more severe in the past ten years, Yarnall-Waring Co., Philadelphia, has produced the Yarway Type C Long Stroke Balanced Seatless Valve designed for the following pressure ranges:

400 lb. per sq. in.
600 " " " "
900 " " " "
1400 " " " "

Operation is made clear by the three illustrations, showing open, intermediate and closed positions.

As in other Yarway Seatless Valves, after valve has closed, shoulder S on plunger P contacts with upper follower gland F, forcing it down into the body, thus compressing the packing P above and below the port. To make this operation of opening and closing the valve easier, heavy ball thrust bearings take the thrusts in both directions.

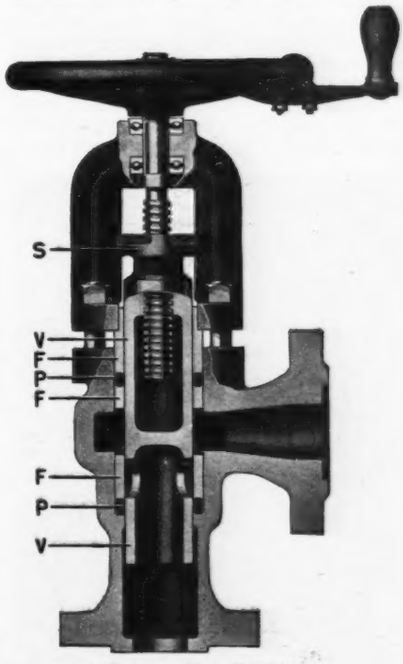
This Yarway Type C Valve has a longer stroke than previous valves so that, when closing, the two ports will have moved down across the follower gland ports, closing the discharge through the valve before the lower packing P has been exposed;—see the intermediate position. Then as the plunger travels



Open Position

still further down, seepage is cut off when these same ports completely pass lower packing, and pressure has been brought upon upper and lower packing by the shoulder S engaging on the follower gland F.

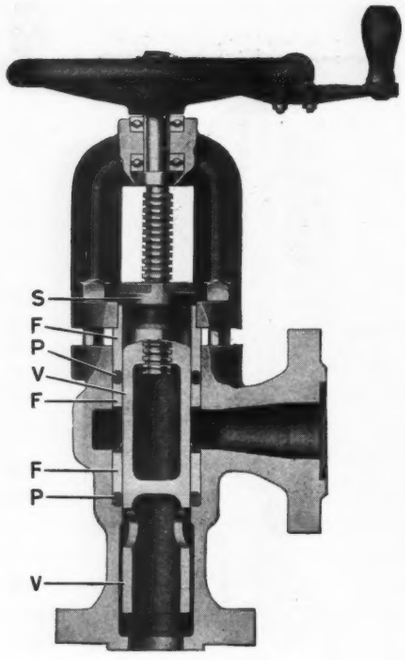
Tandem Blow-off Valves are now in almost universal use, and by using two Yarway Seatless Valves in tandem, the parts are interchangeable, thus requiring but one style of



Intermediate Position

replacement or repair parts for emergency service.

Yarway Type C Valves are made with forged steel bodies for pressures of 1400 lb. The lower packing ring is of the double armored type; the stem of the value is of Class C material; and the plunger is of either chrome steel or nickel bronze alloy, as customer may specify; the yoke studs are also of Class C material.



Closed Position

Improved Boiler Construction Eliminates Seams and Gives Additional Strength

IMPROVED construction in the box headers and also in the longitudinal drums of Heine and Hedges-Walsh-Weidner boilers is announced by Combustion Engineering Corporation, New York.

Box headers have heretofore been made with butt straps for connecting the flanges of the tube sheets and hand hole sheets. While

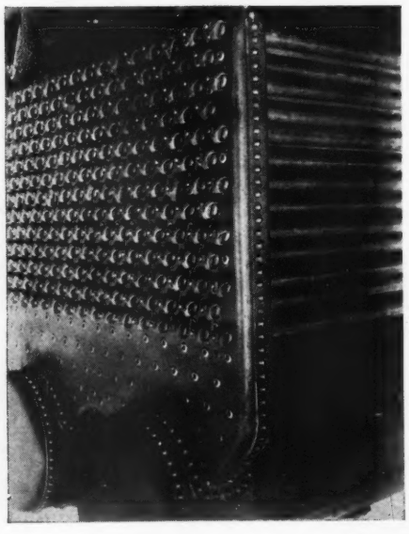


Fig. 1

this has proved an acceptable workable construction, a simpler method of joining these sheets has seemed desirable. An extensive study of this problem has resulted in the construction shown in Fig. 1. The photograph shows a simple overlapping of the flanges of the two sheets. The new construction is both simpler and stronger than the previous construction. In addition, it reduces the thickness of the box header, measured outside to outside of sheets, from 11⅛ in. to 8 in.

Simplicity is obvious. It will also be noted that the lap joint, where the two sheets lie against the drum, has only two thicknesses of metal. With the butt strap, three thicknesses were necessary at this point. There is only one calking seam in the new joint, as against two with the butt strap. The single calking joint of the new construction faces the end of the boiler, so that it is always accessible for observation. The single seam design removes all rivets out of the hot gas and fire zones.

This new construction is much stiffer than with the former design, being strong enough for 450 lb. working pressure, which is a comfortable margin over the 250 lb. pressure for which this type of boiler is frequently used. The stay bolts are, of course, shorter and therefore stiffer. Hollow stay bolts will be retained as standard for horizontally baffled boilers, to accommodate the soot blowing elements, but solid stay bolts will be used for vertically baffled units.

Figure 2 shows the three sheet drum type of boiler with the new box header. An additional feature is shown, in the attachment of the hanger bar clips to the drum. These had heretofore been riveted to the drum, but are now welded on, thus eliminating the rivets and the necessity for calking. It may also be noted that the water circulating space in the box header, with sheets closed in to the 8 in. dimension, remains greater than with any sectional header boiler.

In Figure 3 there is shown a new drum construction, with the shell made from a single plate. It is possible to procure plates large and heavy enough for this fabrication, from only one mill in the world. These plates are rolled to order and are not carried in stock. When this type of drum is used, therefore, sufficient time must be allowed to have the plates rolled for the order. The advantage of eliminating the girth seams is apparent, two of the circular calking seams being entirely done away with, as well as the scarfed joints of the butt straps at the girth seams.

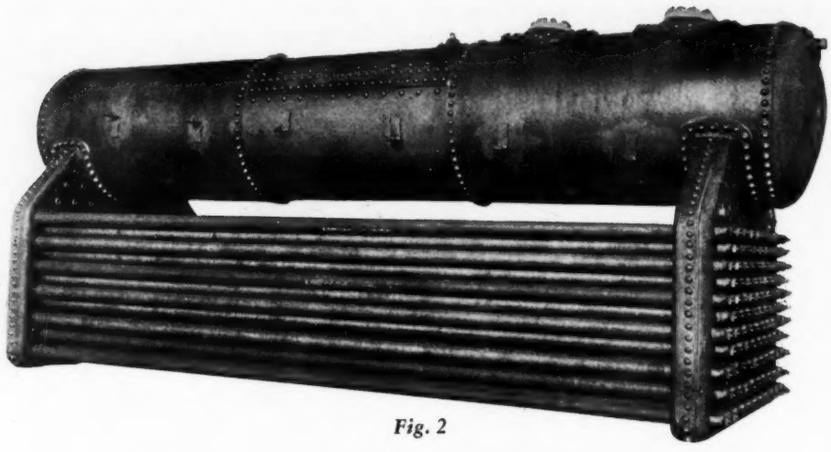


Fig. 2

In Figure 2 the three lower rows of tubes are spaced with a horizontal lane between rows, but the other rows are closer spaced and have no such horizontal lane between rows. This arrangement is used for horizontal baffles. The arrangement of tube rows in Figure 3 shows horizontal lanes between each row of tubes, and admits of the vertical baffle, as illustrated.

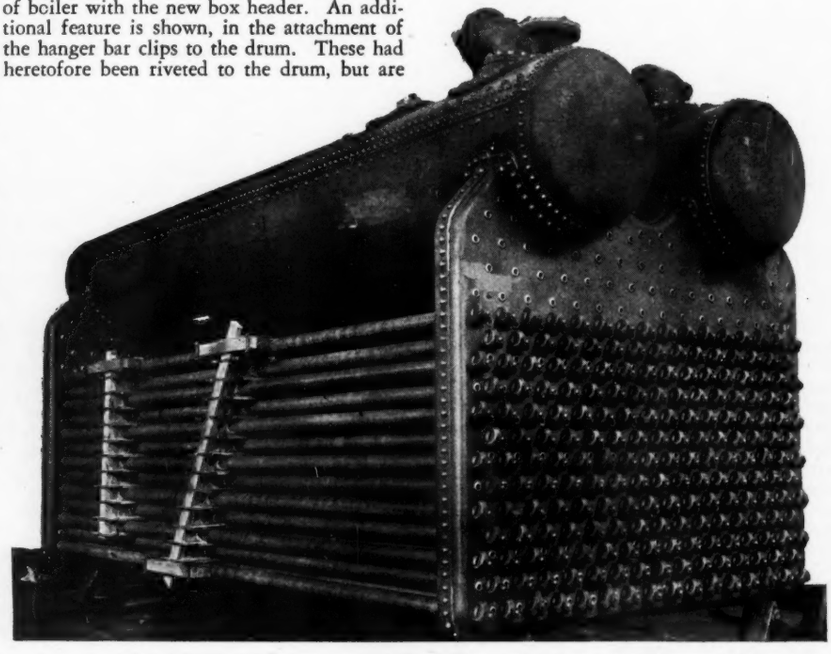


Fig. 3

PATENTS

Recently granted, and of Interest to our Readers.

Printed copies of Patents are furnished by the Patent Office at 10 cents each. Address the Commissioner of Patents, Washington, D. C.

UNITED STATES PATENTS

Issued June 11, 1929

1,716,479. Gas absorber for products of combustion. Jacob Bilsky, now, by change of name, John Gregory Billings, Chicago, Ill. Filed Feb. 9, 1927.

1,716,480. Gas absorber for products of combustion. Jacob Bilsky, now, by change of name, John Gregory Billings, Chicago, Ill. Filed May 18, 1927.

1,716,486. Coal-sizing and impurity-separating device. William F. Davis, Belleville, Ill. Filed July 19, 1926.

1,716,649. Water heater. John W. Miller, East Cleveland, Ohio. Filed June 4, 1927.

1,716,743. Heat-transmitting tube. William Joseph Still, London, England. Original application field Nov. 17, 1926, and in Great Britain Nov. 21, 1925. Divided and this application filed Apr. 23, 1928.

1,716,770. Water-tube boiler. Edward A. Field, Chicago, Ill., assignor to Dangel-Field Co., Chicago, Ill. Filed Apr. 27, 1927.

1,716,815. Method of burning fuel. Thomas M. Chance, Merion, Pa. Filed Feb. 1, 1927.

1,716,921. Heating apparatus. George A. Guenther, Buffalo, N. Y. Filed Nov. 14, 1925.

1,716,982. Liquid-fuel-feeding apparatus. John Scheminger, Jr., Providence, R. I., assignor to Aetna Automatic Oil Burners, Incorporated, Providence, R. I. Filed May 16, 1925.

1,717,015. Boiler. Dexter Edge, Pittsburgh, Pa. Filed Dec. 23, 1925.

1,717,115. Ventilating system for ovens. Harry Paul McCann, Cleveland, Ohio. Filed May 19, 1928.

1,717,334. Furnace. Luis De Florez, Pomfret, Conn., assignor to The Texas Company, a Corporation of Delaware. Filed July 2, 1926.

1,717,350. Boiler. Andrew J. Gallaher, St. Louis, Mo. Filed Jan. 15, 1921.

Issued June 18, 1929

1,717,394. Boiler-controlling device. Oscar H. Ludeman, Glen Ridge, N. J., assignor of one-half to Edwin H. Ludeman, Brooklyn, N. Y. Filed Dec. 29, 1924.

1,717,421. Delivering preheated air to combustion chambers. Gerrit Van Daam, Buffalo, N. Y. Filed Dec. 21, 1927.

1,717,423. Combustion system for furnaces. Gerrit Van Daam, Buffalo, N. Y. Filed Dec. 6, 1927.

1,717,636. View passage for furnaces. Ray P. Vastine, Chicago, Ill., assignor to George M. Vastine, Chicago, Ill. Filed Oct. 31, 1924.

1,717,637. Observation window for furnaces. Ray P. Vastine, Chicago, Ill., assignor to George M. Vastine, Chicago, Ill. Filed Aug. 24, 1925.

1,717,751. Water wall for steam boilers. John F. L. Baker, Saginaw, Mich., assignor to Wickes Boiler Co., Saginaw, Mich. Filed June 2, 1927.

1,717,808. Process of distilling solid carbonaceous material. Carl Postel, New York, N. Y., assignor to American Shale Reduction Company, New York, N. Y. Filed June 11, 1923.

1,717,830. Pulverized-fuel burning apparatus. John E. Bell, Brooklyn, N. Y., assignor to Combustion Engineering Corporation of New York. Filed May 5, 1922.

1,717,989. Locomotive stoker. Nathan M. Lower, Pittsburgh, Pa., assignor, by mesne assignments, to The Standard Stoker Company, Inc., New York, N. Y. Filed July 26, 1926.

1,718,005. Water-cooled buckstay. Louis C. Reis, Duluth, Minn. Filed May 13, 1927.

1,718,032. Fuel-feeding apparatus. Waller Crow and John C. Schaffer, Pittsburgh, Pa., assignors to Schaffer Poidometer Company, Pittsburgh, Pa. Filed Aug. 23, 1920.

1,718,048. High-pressure boiled. David S. Jacobus, Montclair, N. J., assignor to The Babcock & Wilcox Company, Bayonne, N. J. Filed June 30, 1926.

1,718,053. Locomotive and stoker therefor. Nathan M. Lower and Edwin Archer Turner, Pittsburgh, Pa., assignors, by mesne assignments, to The Standard Stoker Company, Inc., New York, N. Y. Filed May 25, 1926.

1,718,054. Locomotive stoker. Nathan M. Lower, Pittsburgh, Pa., assignor, by mesne assignments, to The Standard Stoker Company, Inc., New York, N. Y. Original application filed July 26, 1926. Divided and this application filed Nov. 28, 1927.

1,718,055. Locomotive. Nathan M. Lower, Pittsburgh, Pa., assignor, by mesne assignments, to The Standard Stoker Company, Inc., New York, N. Y. Filed July 9, 1926.

1,718,065. Locomotive. Lonnie Edward Osborne, Pittsburgh, Pa., assignor, by mesne assignments, to The Standard Stoker Company, Inc., New York, N. Y. Filed Mar. 19, 1926.

1,718,104. Vertical drying and dehydrating apparatus. Max Baechler, Paris, France, assignor to Baechler, Kiser et Cie., Paris, France. Filed Nov. 26, 1927, and in France Dec. 4, 1926.

1,718,184. Comminuting solid substances. Walter Ostermann, Barmen-Langerfeld, Germany, assignor, by mesne assignments, to Industrial Spray Drying Corporation, New York, N. Y. Original application filed May 6, 1924, and in Germany May 18, 1923. Divided and this application filed July 13, 1928.

Issued June 25, 1929

17,334. Reissue pulverizing machine. William Kelsey Liggett, Columbus, Ohio, assignor to Jeffrey Manufacturing Company, Columbus, Ohio. Filed Apr. 27, 1929. Original No. 1,621,938, dated Mar. 22, 1927, Serial No. 644,165, filed June 8, 1923.

1,718,233. Method of making boiler drums. Isaac Harter, Dongan Hills, N. Y., assignor to The Babcock & Wilcox Company, Bayonne, N. J. Filed Sept. 9, 1926.

1,718,243. Drier. Povl T. Lindhard, Brooklyn, N. Y., assignor to F. L. Smith & Co., New York, N. Y. Filed Jan. 26, 1928.

1,718,344. Boiler construction. Jay A. Freiday, East Orange, N. J., assignor to Thomas E. Murray, Brooklyn, N. Y. Filed May 27, 1924.

1,718,345. Boiler. Jay A. Freiday, East Orange, N. J., assignor to Thomas E. Murray, Brooklyn, N. Y. Filed Mar. 12, 1927.

1,718,542. Apparatus for drying, charring, and otherwise treating loose material. Otto Dobbelstein, Essen-on-the-Ruhr, Germany; Karoline Dobbelstein executrix of said Otto Dobbelstein, deceased. Filed Dec. 12, 1924, and in Germany Dec. 18, 1923.

1,718,543. Apparatus for drying, charring, and otherwise treating loose material. Otto Dobbelstein, deceased, Essen-on-the-Ruhr, Germany, by Karoline Dobbelstein administratrix, Essen-on-the-Ruhr, Germany. Original application filed Dec. 12, 1924, and in Germany Dec. 18, 1923. Divided and this application filed Dec. 6, 1926.

1,718,544. Apparatus for drying, charring, and otherwise treating loose material. Otto Dobbelstein, deceased, Essen-on-the-Ruhr, Germany, by Karoline Dobbelstein administratrix, Essen-on-the-Ruhr, Germany. Original application filed Dec. 12, 1924, and in Germany Dec. 18, 1923. Divided and this application filed Oct. 24, 1928.

1,718,552. Rotary grinding mill. William H. Fluker, Thomson, Ga. Filed July 15, 1927.

1,718,671. Combustion-arch hanger. Lawrence M. Walsh, Galesburg, Ill. Filed Oct. 29, 1925.

Issued July 2, 1929

1,719,010. Apparatus for indirect generation of steam for locomotives. Otto H. Hartmann, Cassel-Wilhelmshohe, Germany, assignor to Schmidt'sche Heissdampf-G.m.b.H., Cassel-Wilhelmshohe, Germany. Filed Nov. 22, 1926, and in Germany Nov. 23, 1925.

1,719,023. Device for working combustion engines with liquid or pulverized fuels. Rudolf Pawlikowski, Goerlitz, Germany. Filed Aug. 20, 1927, and in Germany Sept. 4, 1926.

1,719,046. Means for indicating change in fluid temperature. Niels Christiansen, Newport News, Va., assignor to Newport News Shipbuilding and Dry Dock Company, Newport News, Va. Filed Mar. 18, 1925.

1,719,070. Automatic control valve. Charles J. Miller, Passaic, N. J., assignor to The Superheater Company, New York, N. Y. Filed Sept. 2, 1927.

1,719,081. Automatic control valve. Emanuel Rawson, Chicago, Ill., assignor to The Superheater Company, New York, N. Y. Filed Sept. 2, 1927.

1,719,090. Oil burner. Thomas B. Stillman, South Orange, N. J., assignor to The Babcock & Wilcox Company, Bayonne, N. J. Filed Nov. 21, 1925.

1,719,183. Surface condenser. John F. Kirgan, Easton, Pa., assignor to Ingersoll-Rand Company, Jersey City, N. J. Filed Oct. 19, 1927.

1,719,209. Baffle. Samuel F. Brooks, Indianapolis, Ind. Filed Oct. 3, 1927.

1,719,327. Boiler. Jonas H. Fox, Seattle, Wash. Filed Sept. 7, 1927.

1,719,385. Steam boiler. Jarrett B. Wood, Tulsa, Okla. Filed June 18, 1927.

1,719,441. Temperature-regulating system. Everett S. Newcomb, Cleveland, Ohio, assignor to Charles Engelhard, Inc., a Corporation of New Jersey. Filed May 23, 1924.

1,719,475. Furnace. David S. Jacobus, Montclair, and Nathan E. Lewis, Plainfield, N. J., assignors by mesne assignments, to Fuller Lehigh Company, a Corporation of Delaware. Filed Oct. 15, 1925.

1,719,593. Gas analyzer. Arthur B. Cunningham, Chicago, Ill., assignor to Republic Flow Meters Co., Chicago, Ill. Filed May 19, 1923.

1,719,599. Cutting device. George Dickson, Chicago, Ill., assignor to The Babcock & Wilcox Company, Bayonne, N. J. Filed Aug. 3, 1925.

1,719,642. Furnace and lining material therefor. Ervin G. Bailey, Cleveland Heights, Ohio, assignor by mesne assignments, to Fuller Lehigh Company, a Corporation of Delaware. Filed Aug. 26, 1924.

BRITISH PATENTS

Accepted May 6, 1929

311,206. Improvements in Means for Controlling the Air Supply to Travelling Chain Grates. Alfred William Bennis, Bolton, County of Lancaster.

Accepted May 8, 1929

311,261. Improvements in and connected with Pulverized Fuel Burners. Babcock & Wilcox, Limited, London.

Accepted May 16, 1929

300,904. Improvements in Coal-dust Burners. Paul Büschler, Nordfeldstrasse, 14, Hannover-Ricklingen, Germany.

311,550. An Improved Method of and Composition for Removing Scale or Incrustations from Boilers or for Preventing the Formation of same. Edward Davies Feldman, 560 West 171st Street, New York, N. Y.

311,506. Improved Construction of Apparatus for Feeding Coal and like Dust to a Burner for Burning in a Furnace or the like. William Thomas Bell, of Globe Works, Canwick Road, Lincoln, and James Frederick Bennett, of Gordon Cross House, Dronfield, Derbyshire, England.

311,505. Improved Construction of Apparatus for Grinding Coal and like Material. William Thomas Bell, of Globe Works, Canwick Road, Lincoln, and James Frederick Bennett, of Gordon Cross House, Dronfield, Derbyshire, England.

311,487. Improvements in or relating to the Conveying and Quenching of Coke. W. J. Jenkins & Company, Limited, of Beehive Works, Retford, Nottinghamshire, and Ralph Morris Goodman, of 17, Victoria St., Westminster, London.

Accepted May 17, 1929

311,787. Improvements in or relating to the Generation of Steam or other Vapour Under Pressure and to the Storage of Heat Energy. Paul Shishkoff, 3 Victoria Street, Westminster, London.

Accepted May 21, 1929

288,566. Improvements in Methods of and Means for Discharging Coke Ovens. The Koppers Company, Pittsburgh, Pa.

Accepted May 23, 1929

298,893. Improvements in Travelling Grate Furnaces. Walther & Cie Aktiengesellschaft, Koln-Dellbruck, Germany, and Max Birkner, Berg-Gladbach, Germany.

312,254. Improvements in or relating to the Burning of Pulverized Solid Fuel in Furnaces, Kilns, or the like. Reginald Joseph Iliffe, and The Buell Combustion Company, Limited, both of Astor House, Aldwych, London, W.C. 2.

312,588. Improvements in Burners for Powdered or other Fuel. Richard Vernon Wheeler, 1 Tapton Park Road, Sheffield, and John Brass, of New Hall, Ardsley, Barnsley, both in the County of York.

311,875. Improvements in and relating to Steam Purifiers and the like. Power Specialty Company, Limited, and Geoffrey Handley Hopewell, both of Aldwych House, Aldwych, London, W.C. 2.

311,889. Improvements in Apparatus for use in Effecting the Exchange of Heat between Fluids. Frank Bailey and Frederick Henry Jackson, both of 64, Bankside, in the county of London.

311,905. Improvements in Pulverized Fuel Burners. Babcock House, Farringdon Street, London, E. C. 4, and Christopher Humphrey Davy, 72, The Avenue, Beckenham, Kent.

Accepted May 23, 1929

312,002. Improvements in Furnace Doors. Edward Williams, 1051 Morgan Ave., Monessen, Penna.

295,384. Improvements in or relating to Water Tube Steam Generators. Sulzer Freres Société Anonyme, of Winterthur, Switzerland.

297,106. Improvements in Coal Dust Furnaces, particularly intended for Locomotives. Georg Hayn, 1, Aschrott-strasse, Kassel, Germany.

303,859. Improvements in or relating to Steam Generators. Compagnie des Surchauffeurs, Rue la Böetie, 3, Paris, France.

311,872. Improvements in and relating to the Supply of Pulverized Fuel to Burners. Edward William Green, of Blackwall Yard, London, E. 14. George Rodham Unthank of 84, Albert Road, Alexandra Park, London, N. 22, and David Dunn, of 43, Rutland Road, Wanstead, London.

Accepted May 27, 1929

312,374. Improvements in and relating to Feedwater Regulators for Steam Boilers. Edward Charles Robert Marks, 57 Lincoln's Inn Fields, County of London, communicated by Northern Equipment Company, 111 West 11th St., New York.

312,380. Improvements in or relating to Furnaces for the Combustion of Pulverulent or Powdered Carbonaceous Materials. James John Cantley Brand, Australia House, Strand, London, W.C. 2, and Bryan Laing, York Mansion, and Petty France, Westminster, London, S.W. 1.

Accepted May 30, 1929

312,460. Improvements in and relating to Mechanical Stokers for Furnaces. George William Johnson, 47 Lincoln's Inn Fields, County of London, communicated by American Engineering Co., Philadelphia, Pa.

312,463. Improvements in or relating to Superheaters suitable for Water Tube Boilers. John I. Thornycroft & Company, Limited, City of Westminster, and Robert Mackie, of Woolston Works, Southampton, County of Hants.

312,470. The Superheater Company, Limited, 195 Strand, London, W.C. 2, communicated by Compagnie des Surchauffeurs, Société Anonyme, of Paris, France.

285,425. Rotary Steam Generator. Aktiebolaget Atmos, of Näckströmsgatan 2, Stockholm, Sweden.

Accepted June 6, 1929

312,702. Improvements in Heat Exchangers. William Henry Owen, 19, Home Park Road, Wimbledon, S.W. 19.

312,702. Improvements relating to the Treatment of Combustible Material. Hans Peter Petersen, 33 Vestergade, Copenhagen, K, Denmark.

297,094. Improvements in Furnaces. American Engineering Company, Philadelphia, Pa.

312,770. Improvements in Mechanical Stokers for Furnaces. Edward Charles Robert Marks, 57, Lincoln's Inn Fields, London, W.C. 2, communicated by Riley Stoker Company, Worcester, Mass.

312,846. Improvements in and connected with Furnace Walls. Babcock & Wilcox, Limited, of Babcock House, Farringdon Street, London, E.C. 4., communicated from Babcock & Wilcox Company, 85 Liberty St., New York.

312,850. Improvements in Steam Separators. William Thomas Hunt, of 1, Humphrey Street, Cheetham Hill, Manchester.

305,469. Improvements in and relating to Beaters for Impact Pulverizing Mills. Hartstoff-Metall Aktiengesellschaft Hamteg of 39 Kaiser-Wilhelmstrasse, Berlin-Cöpeneck, Germany.

306,848. Improvements in and relating to Impact Mills. Deutsche Babcock & Wilcox Dampfkessel-Werke Aktien-Gesellschaft, Oberhausen, Rhineland, Germany, and Ludwig Kollbohm of Christian-Rohlfsstrasse 33. Hagen, Westphalia, Germany